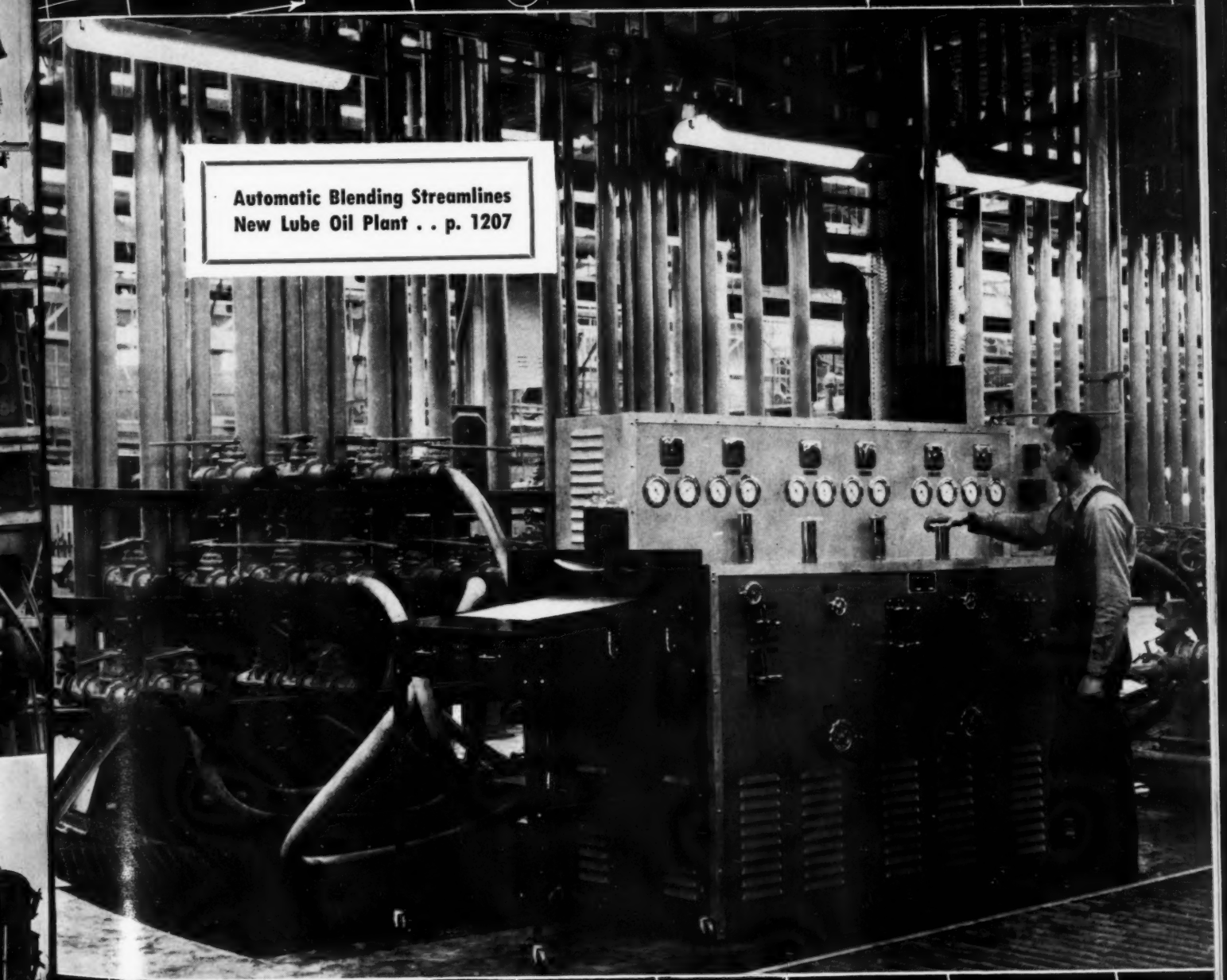
NOVEMBER, 1949
VOL. 4, NO. 11

PETROLEUM PROCESSING



Automatic Blending Streamlines New Lube Oil Plant . . p. 1207

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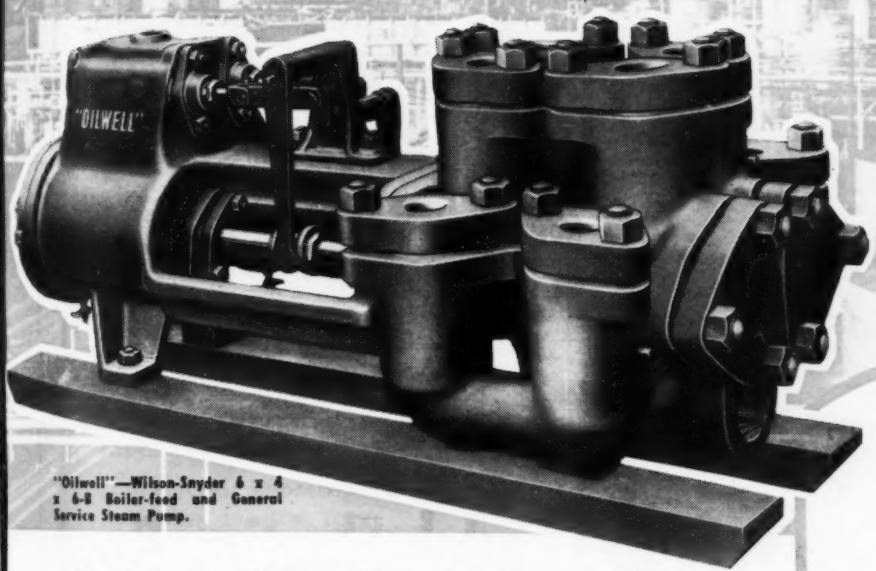

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3	.69	14	21	28	35	41	48	55	62
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Piston Size Inches	Steam Pressure (Pounds per sq. in.)					
	100	150	200	250	300	350
3	400	600	800	—	—	—
3½	295	440	590	735	—	—
4	225	340	450	565	675	790

Working pressures are approximately two-thirds of the stalling pressures.

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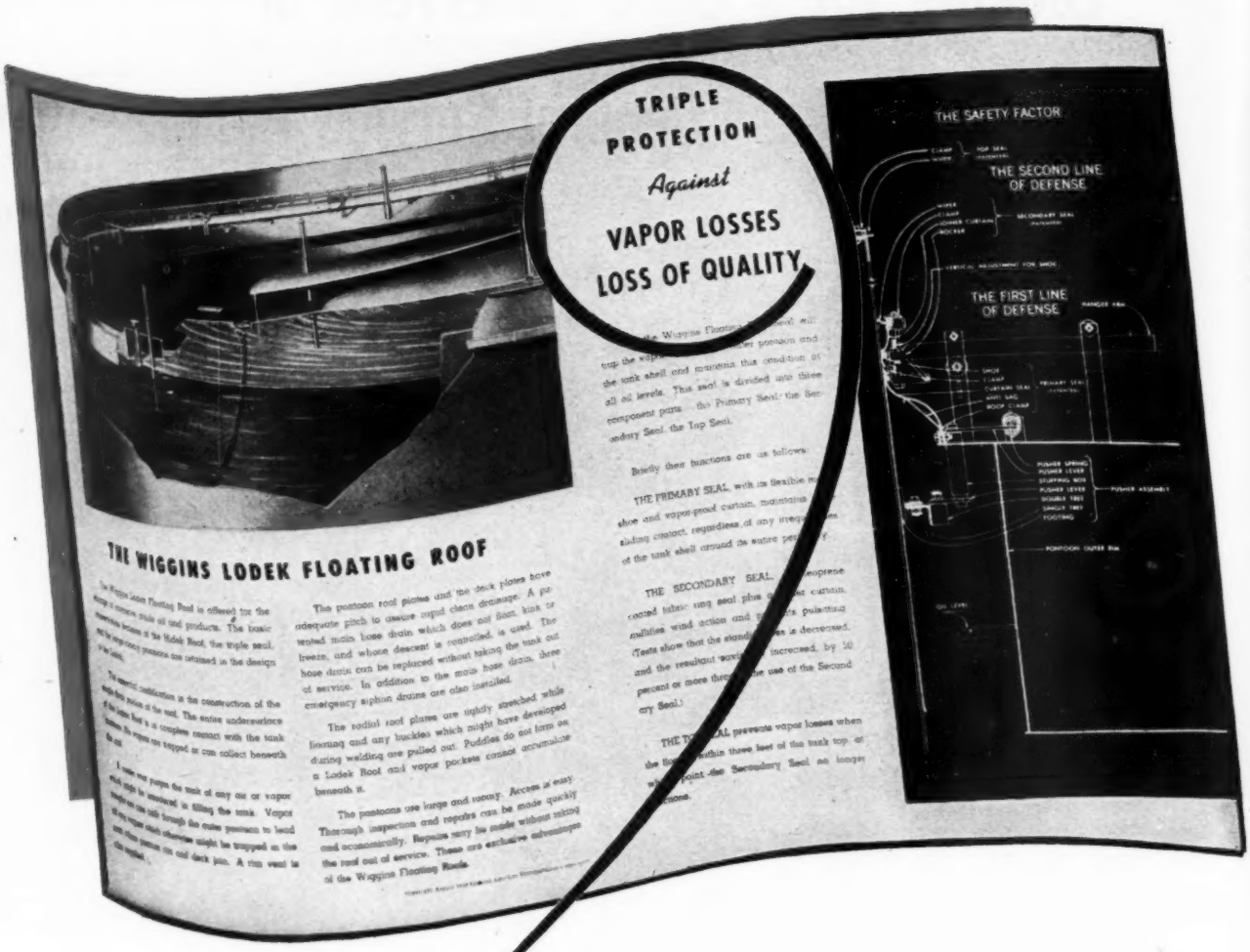

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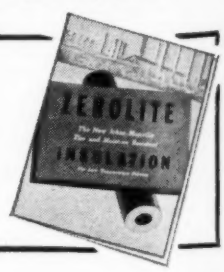

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What's Happening!

Important Current News Summarized for Refiners

EXPANSION

Frontier Refining Co. will install a 2400 b/d 2-coil Dubbs integral coking unit at its Cheyenne, Wyo. plant. The unit is scheduled for completion in late spring, 1950. Unit will produce 105 tons of coke daily and effectively increase existing 2250 b/d of thermal cracking to 3500 b/d. Plant crude capacity is 10,500 b/d with 2500 b/d of catalytic cracking. Universal Oil Products is handling engineering designs and Refinery Engineering Co., Tulsa, mechanical engineering and construction.

Shamrock Oil & Gas Corp. is building a 1500 b/d Perco Cycloversion unit at its Sunray, Texas, plant; completion is scheduled for early 1950. Unit will be operated for both gas oil cracking and naphtha reforming; catalyst chambers will be under completely automatic control.

Supreme Refineries, Ltd., a new company, has secured a building permit in Calgary, Alta., Canada, for a $100,000 plant to handle 500 b/d of black oil from the Lloydminster-Lone Rock area, producing tractor fuel, light and heavy Diesel oil, and asphalts. The initial plant on the 18-acre tract is expected to start operations the first of the year; later in 1950 it is planned to expand capacity to between 750 and 1000 b/d for another $100,000. In the second phase, some Alberta light crude will be processed and lube oils also made by importing residuum oils from Louisiana as well as from suitable domestic crudes.

Consumers Cooperative Assn., Kansas City, Mo., "expects to invest $3,000,000 for additional crude production, may modernize 'world's first complete co-op owned refinery' at Phillipsburg, Kans., and will embark upon an aggressive educational and merchandizing promotion program," according to H. A. Cowden, CCA's president and general manager.

Dispersal of refineries as a defense against atomic bombing is not likely, according to Cmdr. Robert C. Wing, USN. In an article in United States Naval Institute Proceedings, he states that the refining industry is largely "powerless to stem the trend towards concentration of facilities in a few areas," even though it "must face attack by atomic bombing, if war should come."

Little possibility exists for the development of many new and diverse refinery locations, Cmdr. Wing declared, because "The economic laws are such that expansion through integration with existing facilities gives operating economies, lower cost in steel, manpower, utilities and housing savings that cannot be achieved through the erection of completely new units."

• o •

SYNTHETICS

Synthetic liquid fuels will not be needed for another decade, according to A. L. Solliday, executive vice president of Stanolind Oil & Gas Co. Speaking at an AIMME meeting in San Antonio last month, Mr. Solliday stated that the U. S. will have all the oil it needs, even in the event of war, for at least 10 years without synthetic production.

He emphasized that government subsidies of a commercial synthetic fuels industry now would discourage initiative and could actually postpone the development of lower cost techniques. The technology of making synthetic liquid fuels from coal and oil shale, he declared, is in an immature state of development, and the next 10 years should be spent improving present processes and lowering manufacturing and investment costs. This can be done by intensifying research in laboratory and pilot plants, rather than in costly commercial and demonstration plants.

Regarding the sharp contrast in many of Stanolind's cost figures to information released by the Bureau of Mines, Solliday explained that "most of the Bureau of Mines information does not indicate what cost items have been included and what ones have been left out . . . . We feel that in their present form, the Bureau's statements are misleading."

• o •

MARKETS, PRICES

October was a tense month for many refiners. The price spread between crude and products has increased only slightly from the "subnormal" lows of the summer. Some Gulf Independent refiners say that if products continue so plentiful in the nation's spot markets, they might cease refining and buy to cover their 1950 marketing requirements.

Outstanding development of the month was a sharp break in barge prices for heating oils at New York harbor, with kerosine off 0.7c per gallon from the

Information on these pages is obtained through the nation-wide news coverage services of PLATT'S OILGRAM NEWS

8.9c price quoted by most marketers, and No. 2 fuel off 0.875c to 7.625c. Supplies are piling up at New York harbor at such a rapid rate that some majors said their entire East Coast terminal systems were loaded with No. 2 fuel and they were forced to delay cargo arrivals from reserve storage at the Gulf.

Prices for heavy fuel continued to rise, meanwhile, in the prospect of vastly expanded demands of utility and other industrial buyers who have converted from coal to oil. Esso Standard Oil Co. announced a 15c per barrel increase in its No. 6 Bunker "C" fuel prices, effective Oct. 15, at its terminals and refineries at the Gulf and along the East Coast. Esso's advance applied to all classes of trade and at all levels of delivery. The upward trend in heavy fuel prices was followed by most suppliers along the Atlantic Seaboard.

The generally quoted prices for Bunker "C" fuel, ships' bunkers, were $2.05 per barrel at New York, Philadelphia, Baltimore and Norfolk, and $1.75 at Houston, Port Arthur, Baton Rouge and New Orleans. The rising prices on the Eastern Seaboard were watched with more than usual interest by California refiners. The West Coast, with a large products surplus, shows signs of developing as a "new" potential cargo supplier of a complete line of products to eastern wholesalers.

Other prices trends were mixed: Natural gasoline prices were up 0.125c in the Southwest. Quotations for refined grades of gasoline eased in amounts ranging from 0.125 to 0.25c for cargo lots at the Gulf, for tank car shipments, Group 3, and for truck transport loadings out of Chicago terminals. Conventional lubricating oils in the Western Penna. district firmed somewhat, but prices for some grades of solvent refined oils eased 1.5 to 2c per gallon for Tulsa basis shipments. Solvent refined bright stock, 150-160 vis., 0-10 p.p., was available at 19c, Tulsa.

• • •

NATURAL GASOLINE

Work has been completed on the Chalk Hill field (near Wichita Falls, Tex.) natural gasoline plant jointly owned by The Texas Co., Texas Natural Gasoline Corp. and W. A. Moncrief, and operated by Texaco. It has a processing capacity of 1500 Mcf. daily, will produce natural gasoline, propane and LP-Gas.

Shell Oil Co.'s natural gasoline plant near Lucien, Okla., experienced a boiler explosion Oct. 10 which killed one employe. Company hopes to have plant back in operation by Dec. 1; cause of explosion still is undetermined.

Dow Chemical Co. is constructing a compressor station (1320 hp.) and 56 miles of 8-in. pipe line from the Beaver Creek, Mich. oil field to connect to the Dow line at Loomis in order to supply casinghead gas for cracking stock and fuel at its Midland, Mich. plant by shortly after Jan. 1. A similar operation was started Sept. 1 at its Ludington plant, gathering gas from the Pentwater, Mich. field. The two fields will give Dow an estimated 5 to 8 years supply to augment present supplies available at Midland.

• • •

COMPLETIONS

Continental Oil Co. dedicated its $9,500,000 refinery at Billings, Mont. Oct. 8 and started preliminary runs following week. With capacity of 7500 b/d, plant utilizes crude distillation, propane deasphalting of cracking charge stock, Fluid catalytic cracking and desulfurization, plus catalytic polymerization and diethanolamine and doctor treating.

Cit-Con Oil Corp. has shipped the first cargo of bulk oil, high V-I solvent refined neutral and bright stock, from its new 6000 b/d plant at Lake Charles, La.

Gulf Refining Co. last month completed an 18-month expansion and modernization program at its two Ohio refineries—at Toledo and at Cincinnati. Capacity at Toledo was increased about 65%, and at Cincinnati about 15%. New Fluid catalytic cracking units were installed at each plant.

Shell Chemical Corp. now has a new technical service laboratory at Union, N. J., to study chemicals in surface coatings, hydraulic brake fluids and antifreezes, designed to benefit all industries using chemicals from petroleum. Dr. Donald S. Herr formerly of the technical service laboratory at Martinez, Calif., will direct the new lab.

Standard Oil Co. (Ohio) Oct. 19 dedicated its new $11,000,000 Fluid catalytic cracking unit at Lima, Ohio, put on stream a few days previously. The 16,000 b/d unit is the first of three projects to be completed at Lima, the others being a delayed coker and a solvent lube plant.

Ohio Oil Co. early last month completed its modernization program at Robinson, Ill., which included a new 12,400 b/d Fluid unit.

• • •

TRANSITIONS

Sunray Oil Corp.'s 7000 b/d Allen, Okla., refinery was shut down Nov. 1 for an indefinite period for necessary cleanout and repairs. Resumption of operations, company said, will depend largely on delivery of new tankage for product storage and development of more flexible operation in pipe line delivery.

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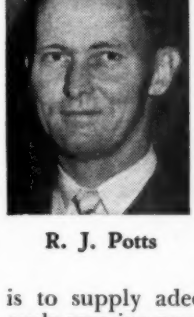
A SERVICE ORGANIZATION

Farm Bureau to Install Fluid Cat Cracking Unit

By R. J. Potts
Superintendent, Refinery Division, Indiana Farm Bureau Cooperative Association, Inc.

THE installation of a UOP Improved Fluid Catalytic Cracking Unit which is planned for our refinery at Mount Vernon, Ind., is a major step in a continuing program pointed toward increased capacity and improved operating efficiency.


R. J. Potts

We believe that our new cat cracker, together with other improvements which we have contemplated, will place us in a better position than ever before to perform our function, which is to supply adequately the continuously growing number of our customers with high quality gasoline and other petroleum products.

Plan for the Future

Our plans do not stop with producing gasoline to meet today's—or tomorrow's—standards. We are looking far into the future. The trend of automotive engine design today points to steadily increasing compression ratios which will require motor fuel of higher octane rating than the premium gasoline of today and the improvements now planned will enable us to keep step with the advancing "march of the octanes" for years to come. It is expected that with the aid of the new facilities, of which the cat cracker will be the key, the refinery will produce about 71% of gasoline, based on crude. With three cc of tetraethyl lead, approximately 40% of this gasoline will have 94 octane rating, and the remainder 86 octane (Motor Method).

When the new operation is in effect, running our present daily capacity of 8,000 barrels of Illinois Basin crude, yields of products are expected to be as follows:

	Barrels
Gasoline (including poly)	5,660
Kerosene	400
No. 6 Fuel Oil	1,540
Butane	120

In addition, the production of fuel gas will be sufficient to develop 116,000,000 Btu per hour, enough to supply the fuel needs of the plant.

Cat Cracker Has Single Column

The cat cracker will have the reactor and regenerator housed in a single column. Its design capacity will be 3,640 b/d at 55% conversion which is more than one and one-half times the original crude capacity of our refinery. A saving will be effected through omitting the flue gas waste heat boiler which is usually a part of the UOP design.

(Advertisement)

The boiler is unnecessary at present because of the large quantity of gas available for fuel.

The cat cracker and other new facilities will be designed and engineered by Universal and built by our own refinery forces.

Other Equipment

The current project includes, in addition to the cat cracker, a new vacuum unit and a gas concentration system. Design capacity of the former will be 3,200 b/d of reduced crude. Its function is to produce vacuum gas oil as charge to the cat cracker.

The gas concentration unit is a three-column system designed to recover approximately 75% of the propane and over 95% of the butane from the gas. It will include a reboiler stripper for removing the H_2S from the gas to be charged to the UOP catalytic polymerization unit, which is a part of our existing plant. This unit is producing 120 b/d of 82 octane polymer and will be enlarged to handle the increased volume of cracked gas and to produce about 300 barrels of polymer daily.

When market conditions warrant, bottled gas, or LPG, can be produced with only minor changes.

The UOP 2-coil thermal cracking unit, which also is a part of our existing plant, will be operated to the best advantage as an adjunct to the cat cracker. The capacity of the thermal cracker was recently enlarged for this purpose by the addition of a second reaction chamber. This added about 300 b/d to its capacity.

The catalytic cycle stock, together with vacuum bottoms and miscellaneous virgin stocks, totalling about 2,760 b/d, will be processed in the thermal cracker, which is flexible enough to permit the cracking of kerosene.

While some existing elements will be used, most of the equipment will be new, purchased by the Franklin Supply Company, Chicago.

Built in 1940

The 10-year history of our refinery has been a record of consistent progress. It was built from the ground up, in 1940, by our Association, to process crude from the nearby Griffith pool and supply Farm Bureau members in Indiana with gasoline and other petroleum products. The original plant consisted of a 2,000 b/d skimming unit.

As motor fuel consumption and octane requirements steadily increased, it became necessary for us to produce more and better gasoline. To this end we started construction of the thermal cracking unit above referred to which went into operation in June, 1946.

The next step was the installation of the modern 8,000-barrel crude unit placed in operation in September, 1948.

Today the plant is running four times as much crude as its original capacity and producing gasoline and other products of a quality impossible to achieve when the original refinery was built.

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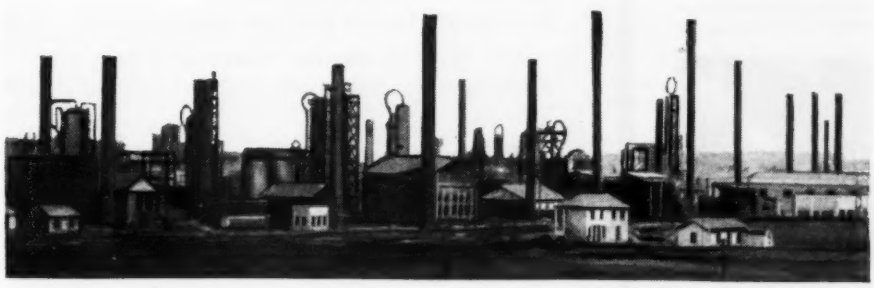

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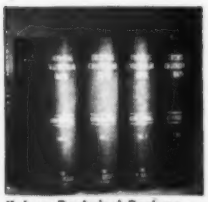

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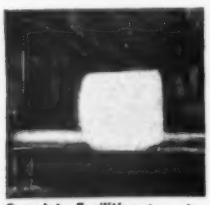

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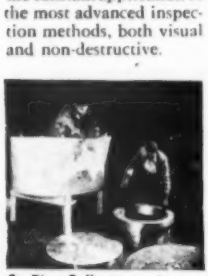

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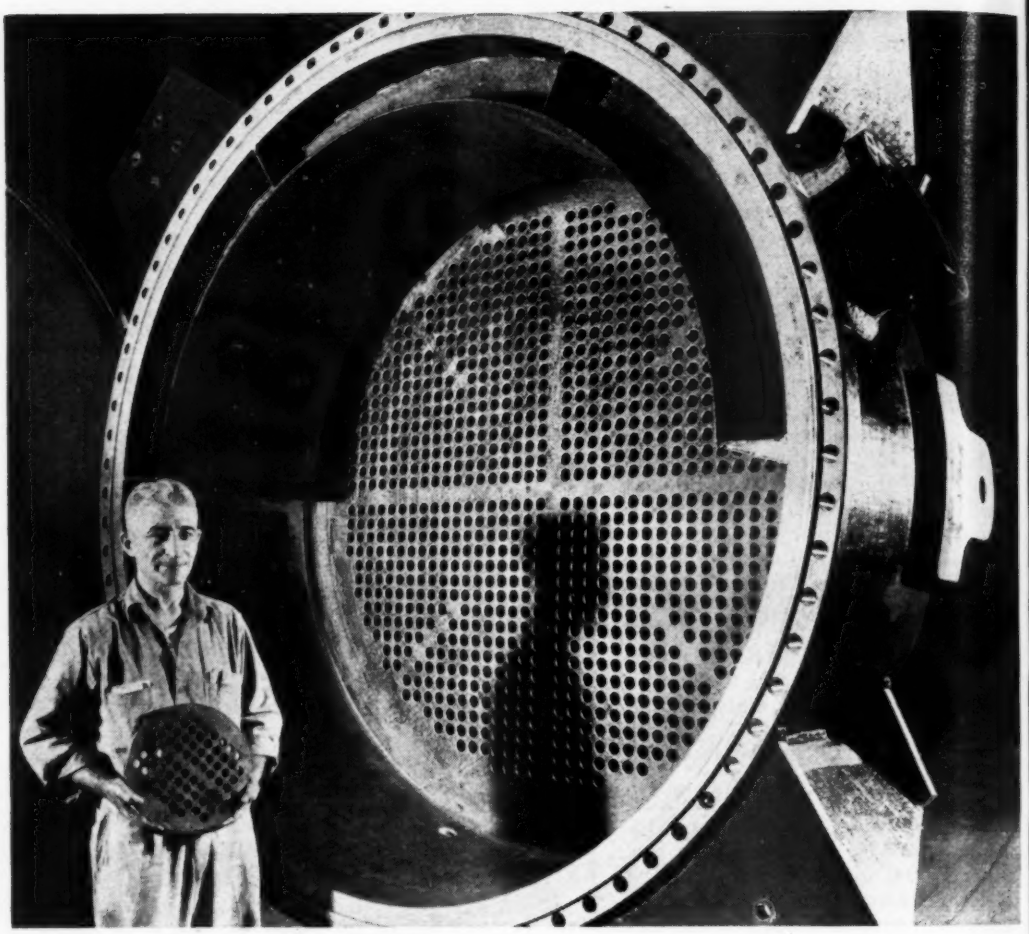

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Tomorrow

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By B. H. WEIL, Atlanta, Ga.
Editor, "Monthly Summary of Industrial Developments"

Brief reviews of currently reported technological and economic developments, in the light of their potential bearing on petroleum refining

Adsorption Combined With Desulfurization

THE symposium on the uses of adsorption in petroleum refining, a feature of the sessions of the Division of Petroleum Chemistry at the ACS meeting in Atlantic City, Sept. 18-23, received unusual attention. One paper presented seemed highly significant in this age of attention to desulfurization, "Application of the Cyclic Adsorption Process to Desulfurization of Cracked Naphtha", by Sam Eagle and Charles E. Rudy, Jr., of the California Research Corp. An article on the process was also presented in this journal.(1)

Hydrodesulfurization of naphthas is a sulfur elimination method of good technical repute, on which extensive research has been conducted. As is well known, however, the use of this process in connection with cracked naphthas causes saturation (hydrogenation) of the olefinic hydrocarbons present in addition to elimination of sulfur, with concurrent losses in octane numbers, sometimes as high as 10-12 units.

What Eagle and Rudy propose, however, is the use of a cyclic adsorption process to separate cracked naphthas into a paraffin-naphthene-olefin raffinate and a high-sulfur aromatic extract, after which the extract is hydrodesulfurized and the resulting product reblended with the adsorption raffinate to yield a premium low-sulfur gasoline blending component.

Silica gel was used as the adsorption medium in the work reported, the study being based on the observation that the sulfur compounds present seem confined almost completely to the aromatic part of the naphtha. Pentane was employed as the stripping liquid. Dehexanized naphthas were extensively studied, although it was stated that depentanized naphthas constitute the preferable feed stock.

The economics of the process were not stated and are not clearly evident, but the combination of adsorption with hydrodesulfurization at least renders the latter process technically applicable to use with cracked naphthas, something not previously practical because of the aforementioned loss of octane numbers. More details on this combination process will be awaited with interest.

New Types of Jet Fuels Are Receiving Study

AS Dr. Gustav Egloff of Universal Oil Products Co. recently told a UN conference on the conservation and utilization of resources, "jet propulsion of aircraft has created new fuel problems. The requirements for jet fuels are not completely known, and a large amount of experimentation is in progress to develop appropriate fuels." High fuel consumption —sometimes five times that of counterpart reciprocating engines—was cited as a problem whose solution is imperative. "A satisfactory fuel must burn rapidly and completely, have very high heating value per unit weight, and low freezing point." According to Egloff, tailor-made hydrocarbons for jet fuels will probably be developed in a manner similar to the development of products and processes for manufacture of high-octane aviation gasolines.

The fuel problem in the case of ram-jet engines has recently been reviewed.(2) According to the author, James W. Mullen, II, of Experiment Inc., "the fundamental fuel property most closely related to potential thrust is the heat of combusion per unit weight of air." Fuel storage space is generally very critical, so that the density of the fuel, or the heat of combustion per unit volume, is very significant. "Overlooking certain difficulties, otherwise desirable fuels such as liquid hydrogen have their value lessened somewhat because of their low densities. Some high molecular weight hydrocarbons offer as much as a 25% advantage in Btu. per gallon over those in the gasoline range."

The following fuel properties are said to be significant: "The boiling point and heat of evaporation are influential in determining fuel phase distribution, the air temperature in the ignition region, and the final exhaust temperature. The static inflammability limits partially extrapolate to the high velocity regime. The ignition temperature for very short lags and the normal flame velocity have, in some instances, served to predict fuels having improved performance and higher efficiencies, particularly near the combustion limits. The heats and free energies of formation and combustion sometimes serve the same purpose.

"The search for improved fuels has included solids such as coal, wood, and the lighter metals, magnesium, aluminum, etc., because of their favorable densities and heats of combustion per unit weight of air. The full gamut of organic materials has been tested. The metal organic compounds and metal hydrides have been considered, both as main fuels and as catalysts. Also considered have been additives which lower the ignition temperature, such as have been found useful in raising the cetane number of Diesel fuels, e.g., the low molecular weight aldehydes, organic peroxides, and nitrates. While fuels have been found that offer advantages in one or more respects, no possibility in the realm of electron chemistry appears for increasing burner performance by as much as an order of magitude."

Another source also reports that the Armed Forces have been experimenting with powdered aluminum, which may be 2.5 times as effective as an equal amount of gasoline—meaning possible doubling or tripling the range of jet planes.

The petroleum industry, as can be seen, holds no monopoly on the sources of combustible materials, although it does have two advantages over competitors: (1) large output and (2) lower product prices. As Dr. Egloff mentioned, much petroleum industry research is being conducted on improvements in product quality, and these may be expected to keep pace with improved jet engine designs—and increased jet engine use.

Chemical Energy Changed Into Mechanical Energy?

IN this age of potential industrial use of atomic (nuclear) energy, a recent news item(3) might pass almost without notice were it not for the interesting connotations engendered:

"The direct conversion of chemical energy into mechanical energy is a possibility that may result from work at the Weizman Institute in Israel. A physical chemist and biologist have duplicated human muscle activity with methylvinylacrylic rubber which responds to electrical stimuli furnished by acids and bases, expanding and contracting as does a human muscle. Now the scientists are developing an engine based on these findings, ex-

pected to be operating in about three months. Strips of the synthetic material will be placed in a container with water and connected by a rod to a wheel. Two containers with alkali and acid will provide electrical charges, which will keep the strips expanding and contracting in a piston-like fashion. They, in turn, will motivate the rod, and keep the wheel spinning. Direct conversion of chemical to mechanical energy would result in a 20-30% gain of efficiency in energy utilization."

Whether such an increase in efficiency is actually attainable—and by this method—remains to be seen, but the whole development will bear watching. It is far-fetched immediately to envision automobiles and industries powered in this manner—an event which would call for vast quantities of inorganic chemicals, synthetic rubber, etc.—but it is never wise to ignore possible competition. Who knows what this might mean?

Hydroformer Polymer Finding New Use

HYDROFORMING — catalytic dehydrocyclization in the presence of recycled hydrogen—is a versatile process. It has proved of considerable merit for the octane-number upgrading of naphthas. During the war (and since), its products have yielded toluene (by extraction) in large quantities at economic price levels. Early last year, considerable attention was focused on the fact that condensed, alkylated aromatics similar to those produced as by-products were of potential value in the field of wood preservation.

It is therefore interesting to note that this same "polymer" is receiving attention in other fields. According to *Chemical Industries*,(6) "several oil companies are quietly investigating formaldehyde condensation resins made from the so-called 'polymer' obtained as an unavoidable by-product of hydroforming of heavy naphtha in gasoline manufacture. This 'polymer' is rich in naphthalene and, more especially, alkyl naphthalenes. Certain fractions of it, when condensed with formaldehyde, give a 75-85% yield of a resin which in preliminary tests has shown excellent results in linseed and tung oil varnishes."

As mentioned previously in this series, the condensed (multi-ring) aromatics are becoming of great interest in many quarters. Whether they are derived from coal tar, coal hydrogenation products, or hydroforming "polymer" is of little concern to their users, except as regards prices, but it is safe to say that the potential competition among producers will attract attention even from sideliners.

Chemicals from Synthetic Liquid Fuel Processes

THE impact on the organic chemical manufacturing industry resulting from the production of chemicals as by-products of synthetic liquid fuel plants may be considerable, it has already been recognized. Some pertinent data on the subject are given in a recent government report on its experimental synthetic liquid fuel program.(5) The by-products and chemicals possible from the hydrogenation of coal are reviewed, as in the Fischer-Tropsch and related processes; also the character of the oils produced during the hydrogenation of coal under various conditions in the Bureau of Mines experimental plant at Bruceton, Pa.

"Important by-products from the Fischer-Tropsch synthesis are water-soluble organic chemicals, such as ethyl alcohol, acetic acid, and acetone," it is brought out. These products will be available in sufficiently large quantities to have a tremendous economic effect upon established sources and uses. They may become the principal source of many basic organic chemicals, particularly those used in the cellulose plastics and fibers, acetate rayon, pharmaceutical and aliphatic solvent industries."

The development of by-product chemicals from the operation of the fluidized iron catalyst process in the Hydrocarbon Research plant at Brownsville, Texas, will strike with greatest force on the acetic acid industry, it is stated. Anticipated acetic acid production from the Brownsville plant is nearly 25,000,000 pounds annually. Production from 10 such plants would about equal the present total production in the U. S. In addition other by-product raw materials could be easily converted to acetic acid. The future course of the fibers and plastics industry in this country may be greatly affected by the development of by-product chemicals from synthetic fuels manufacture if of this magnitude.

"The impact of this new source of chemicals will also be felt on ethyl alcohol, already under strong competition from methyl and isopropyl alcohols," the government report states. "If the volume of ethyl alcohol used as antifreeze were lost to competitive materials, production estimated from 10 Fischer-Tropsch plants would supply more than enough alcohol for the remaining demand."

An additional channel of use for alcohol that does not exist for the acids, it is pointed out, is for motor fuel and it is inferred that production of alcohols from synthetic fuels plants could be disposed of at about the price of gasoline.

A statement such as the above needs the support of economic factors, and the report in question is entirely without consideration of the economics phase of the subject. It seems faulty logic to assume that 10 commercial synthetic fuel plants will be constructed of the type of the Brownsville plant, which uses natural gas as raw material, because of the growing demand for this fuel in its natural state. The manufacture of by-product chemicals from solid materials in synthetic liquid fuels plants will be an entirely different matter as regards economics and possibly technologically as well.

New "ACF-Talgo" Train May Affect Diesel Demands

THE recently unveiled "ACF-Talgo" train represents concepts in railroad vehicle design which may well have far-reaching effects on the railroads' use of Diesel fuels.

Built by American Car & Foundry, the new train is based on work done originally in Spain. Three of the trains are being built—two for service in Spain and one (now in service) for experimental work in this country. Main visible feature of the Talgo is its use of a coach consisting of five articulated units, each with only one pair of wheels, at the rear, the front end resting on the unit ahead.

Outstanding feature of the new train from the oil industry's viewpoint is the tremendous weight reduction. One Talgo coach of five units weighs less than one-fourth as much as present streamline passenger equipment of equivalent capacity.

Motive power for the experimental Talgo (Diesel-electric locomotive, baggage unit, and 64-passenger coach) is supplied by two 8-cylinder automotive-type Diesels of 405 HP each. Fuel requirements, according to ACF, are the same as for present Diesel-electrics, as far as quality—but it is obvious that the appetite of an engine pulling a payload equivalent to but weighing only one-fourth that of present trains will be greatly lessened. Although the railroad industry is slow to adopt new ideas, refinery operators attempting to predict future Diesel fuel demands will do well to watch the Talgo.

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(1) Eagle, S. and Scott, J. W., "Refining by Adsorption," PETROLEUM PROCESSING 4, No. 8, 881-84 (1949).

(2) Mullen, James W., II, "Burners for Supersonic Ram-Jets, General Aspects of the Problem," *Industrial and Engineering Chemistry*, 41, No. 9, 1935-45 (1949).

(3) Anon., "Direct Conversion of Chemical Energy Reported," *Chemical and Engineering News*, 27, No. 35, 2490 (1949).

(4) Anon., "Newsletter," *Chemical Industries* 65, No. 2, 181, 182 (1949).

(5) Golumbic, Norma, "Some Chemicals from Synthetic Liquid Fuels Processes", Report of Investigations 4467, U. S. Bureau of Mines.

(6) Anon., "Newsletter," *Chemical Industries* 65, No. 2, 181, 182 (1949).

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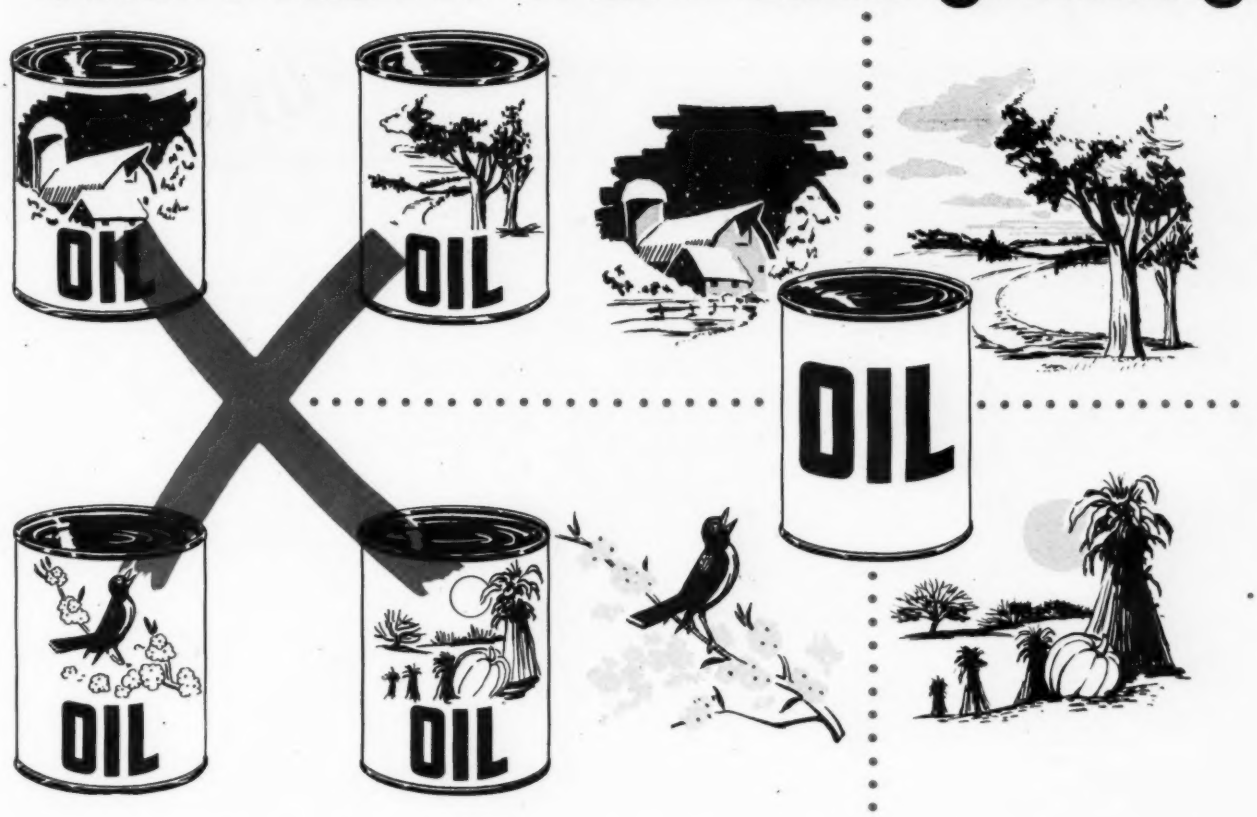

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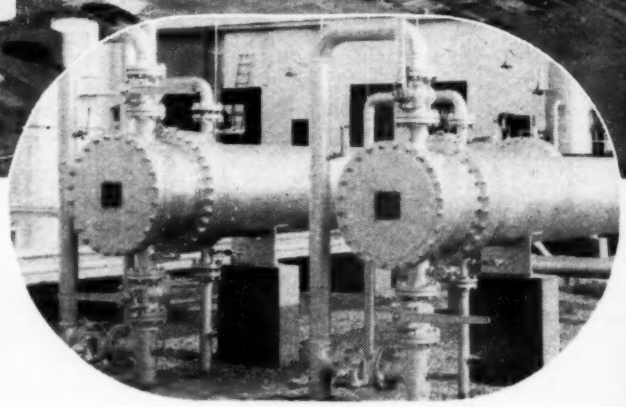

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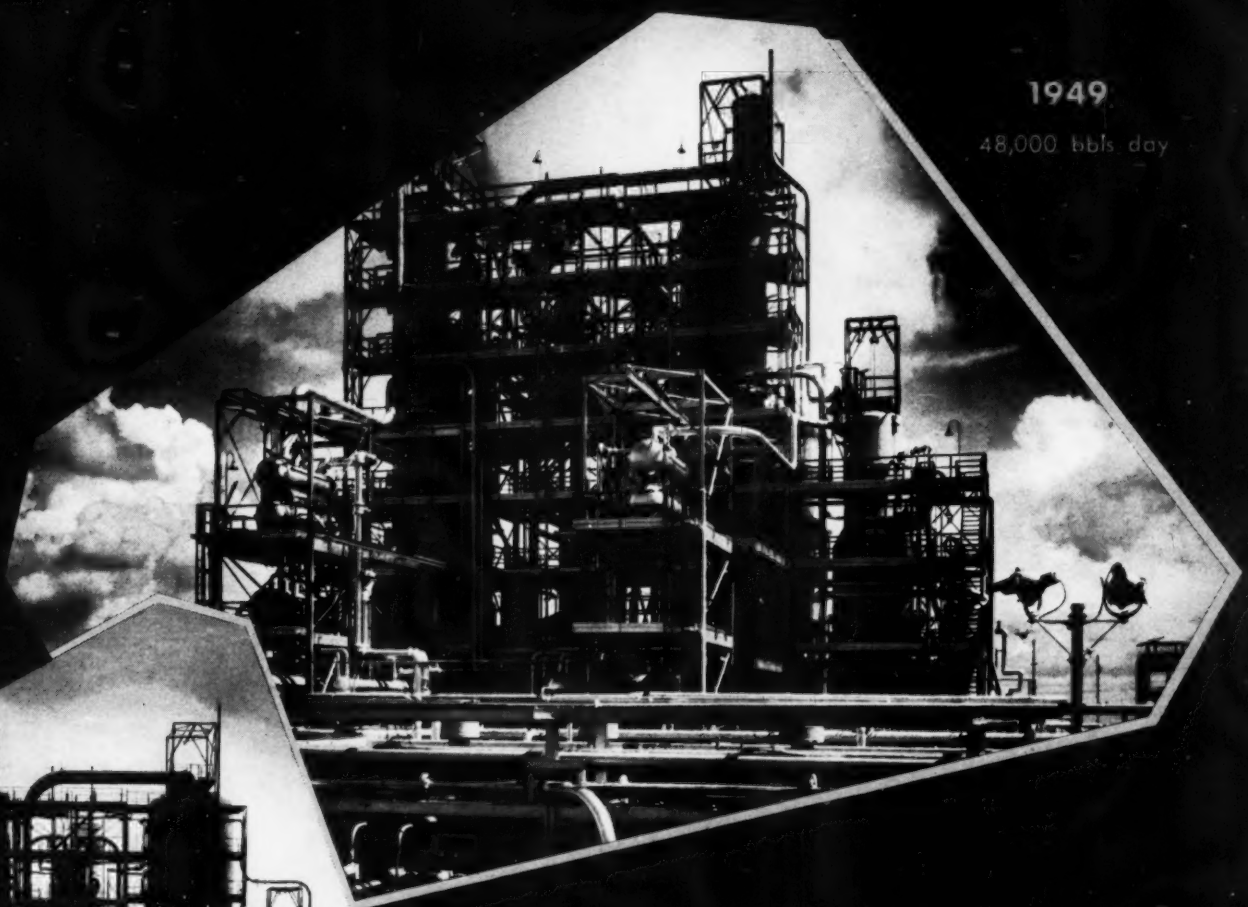
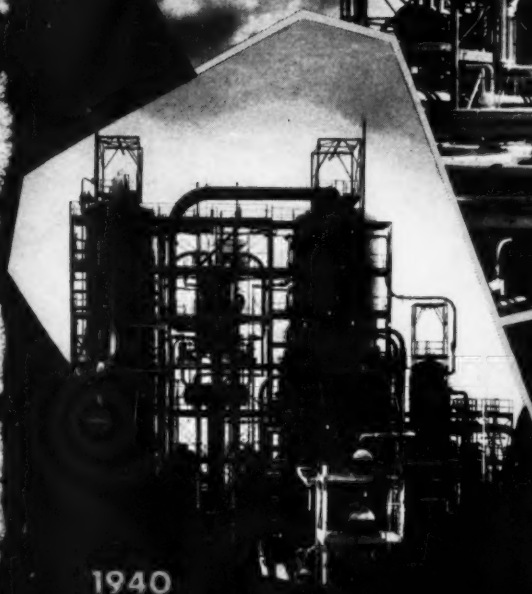


1949

48,000 bbls day



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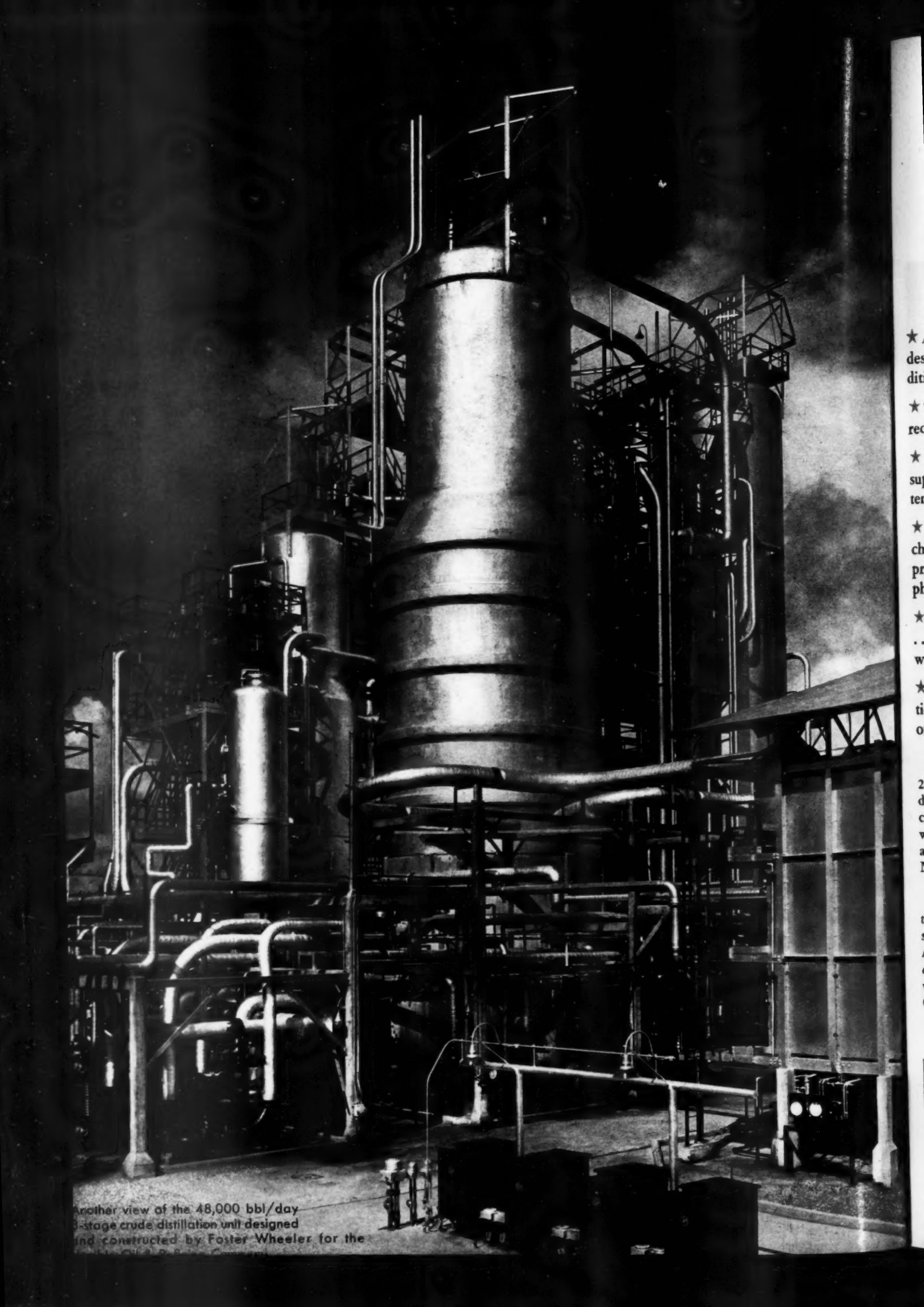

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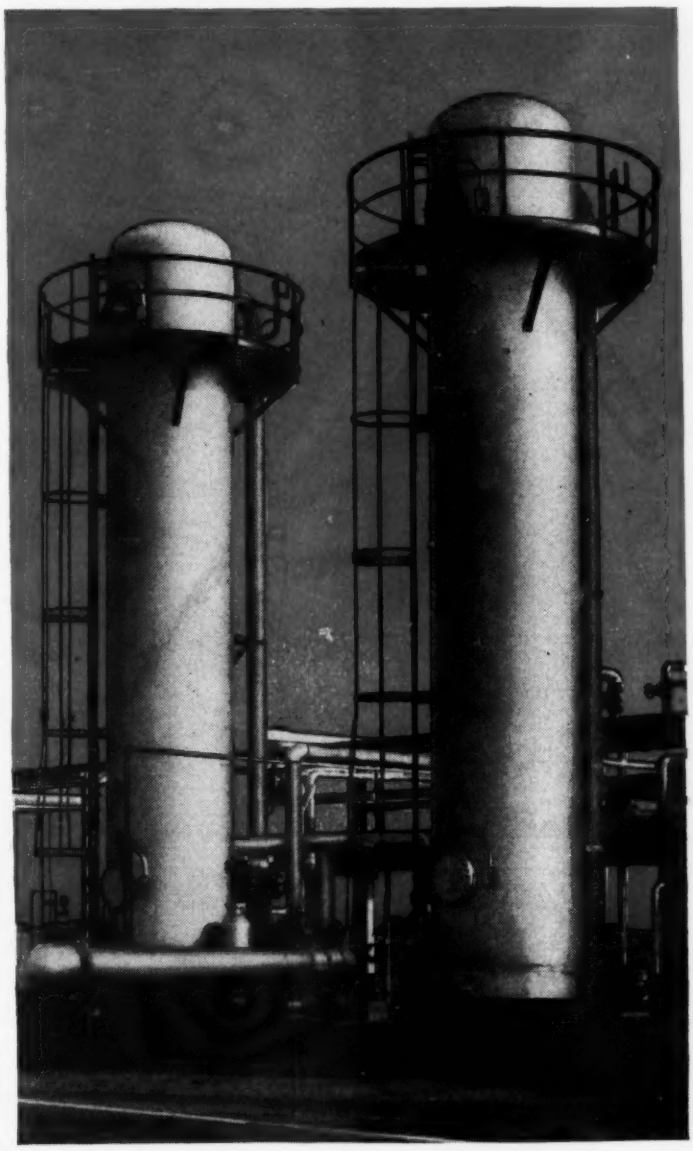

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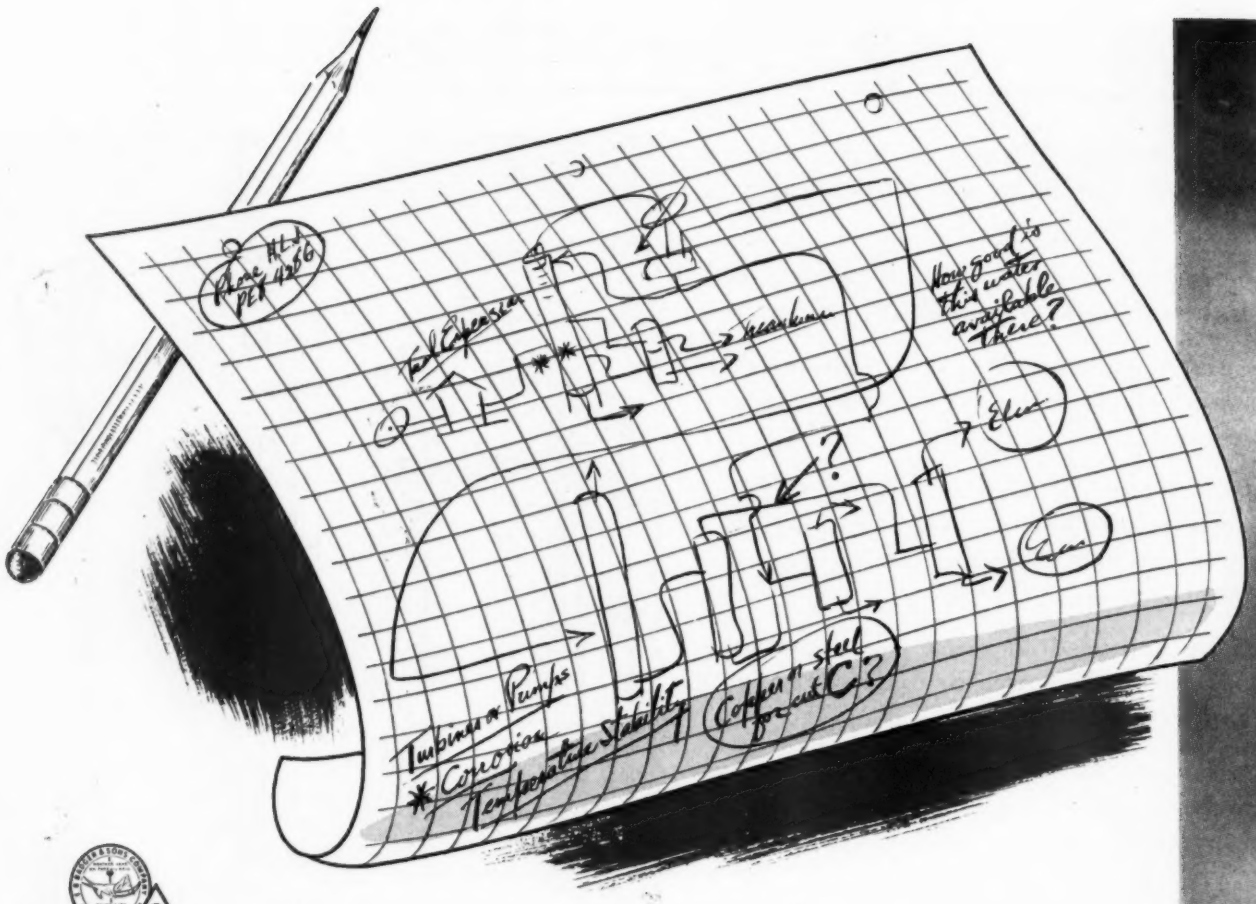

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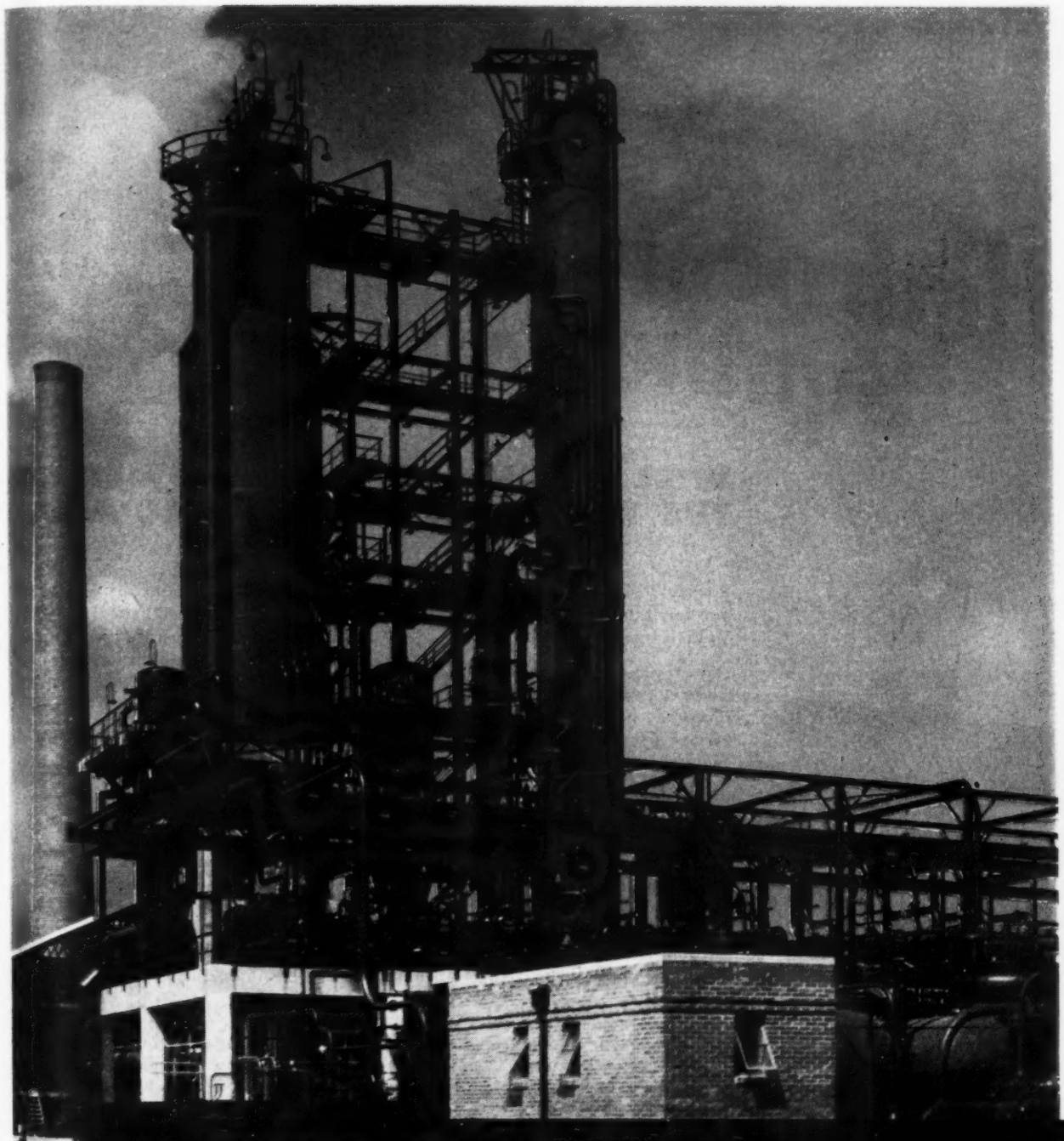

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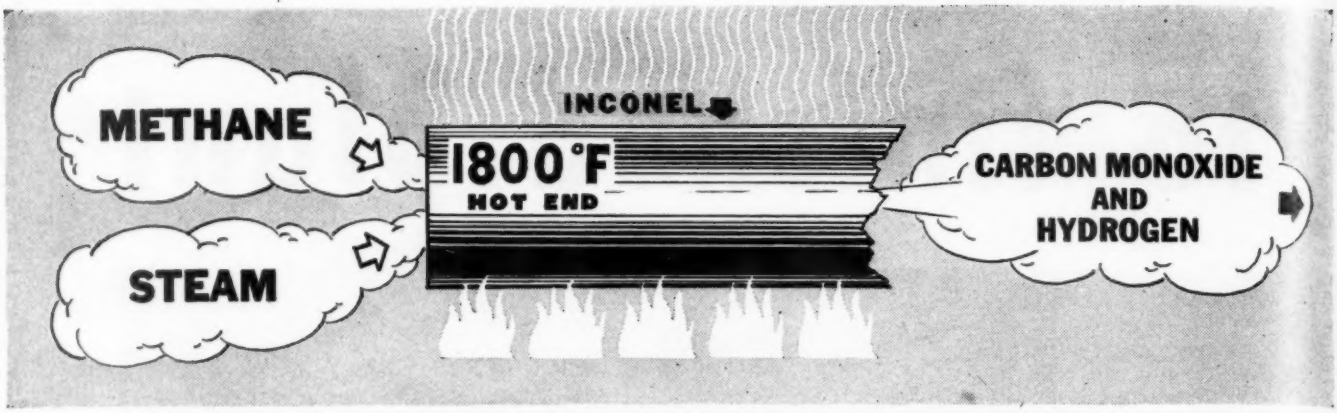

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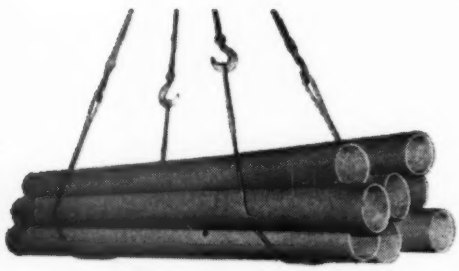

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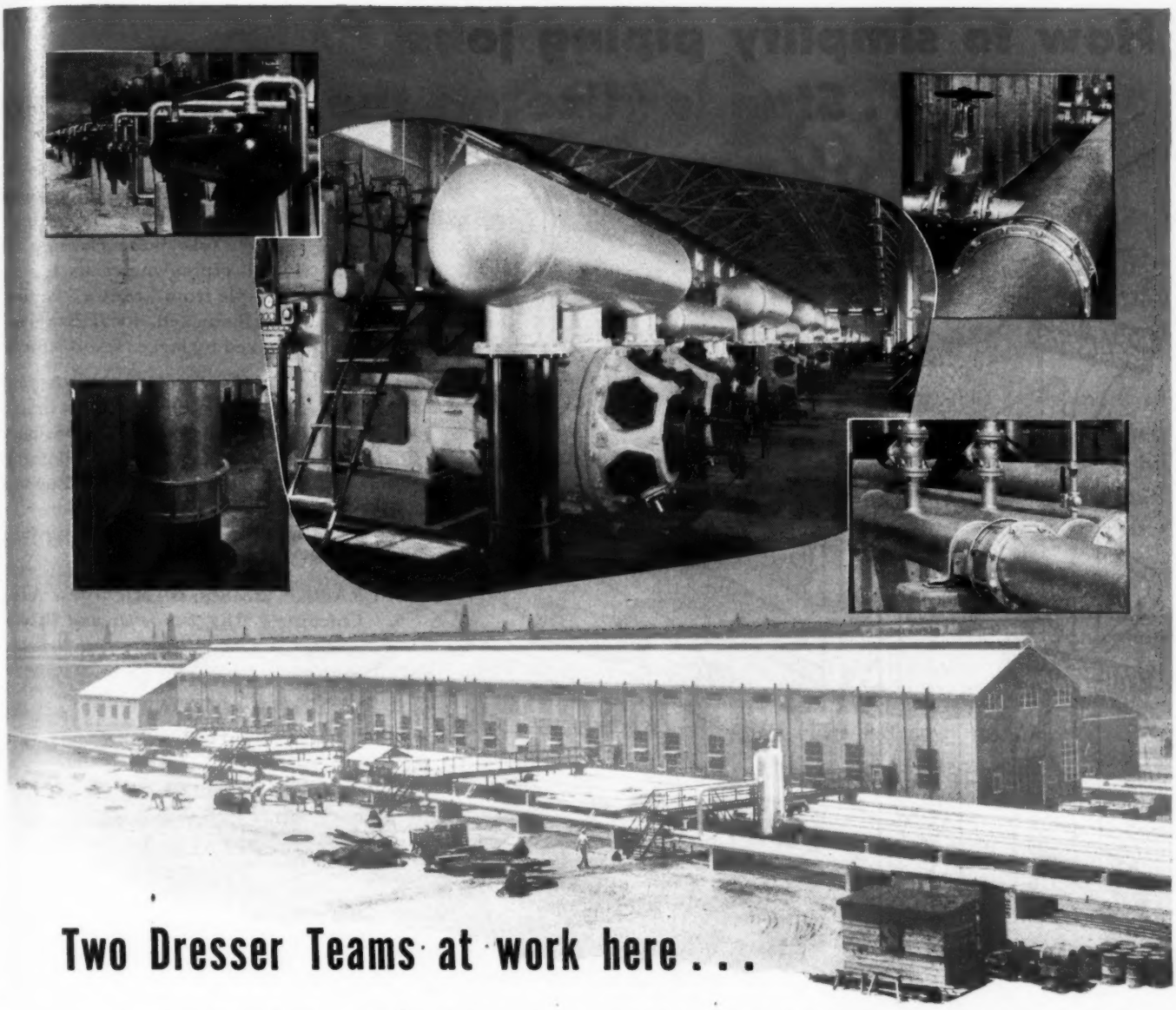
DESIGNERS and MANUFACTURERS! Sand|castings|and precision castings of Monel*, Nickel, Inconel* and other Nickel alloys are available from Inco's own foundry, backed by a half century of experience with Nickel and Nickel Alloys.



Two Dresser Teams at work here . . .

Here are shots from the heart of one of the newest and most advanced natural gasoline plants in the country. The battery of compressors and the oil coolers were built by Clark Bros. Pipes to the jacket water reservoir, the jacket water cooler and pipe for fuel gas are coupled with vibration-absorbing, flexible couplings built by Dresser Manufacturing Div.

DRESSER INDUSTRIES is being called on to help engineer the most modern installations in the oil and gas industry because its ten subsidiaries have the highly specialized facilities of independent experts in their several fields. But through Dresser Industries, the engineering departments co-operate to achieve installations co-ordinated in equipment and over-all design. This produces the highest efficiency and greatest economy which is why the biggest jobs are going to Dresser.

Inquiries and requests for literature may be addressed to Dresser Industries, Inc., Terminal Tower, Cleveland 13, Ohio.

DRESSER INDUSTRIES INC.

TERMINAL TOWER • CLEVELAND 13, OHIO

THE ONLY COMPANY DOING AN OVER-ALL JOB } *from well to refinery for the Oil Industry— from source to consumer for the Gas Industry*

BOVAIRD & SEYFANG Manufacturing Company, Bradford, Pa. • **CLARK BROS.** Company, Inc., Olean, New York • **DRESSER** Manufacturing Division, Bradford, Pa. • **DRESSER** Manufacturing Company, Limited, Toronto, Ontario, Canada • **INTERNATIONAL** Derrick & Equipment Company, Beaumont & Dallas, Texas; Torrance, California; Columbus, Marietta & Delaware, Ohio • **KOBE**, Inc., Huntington Park, California • **PACIFIC PUMPS** Inc., Huntington Park, California • **ROOTS-CONNERSVILLE** Blower Corporation, Connersville, Indiana **SECURITY ENGINEERING** Co., Inc., Whittier, California • **STACEY BROS.** Gas Construction Company, Cincinnati, Ohio; **STACEY-DRESSER** Engineering Division, Cleveland, Ohio

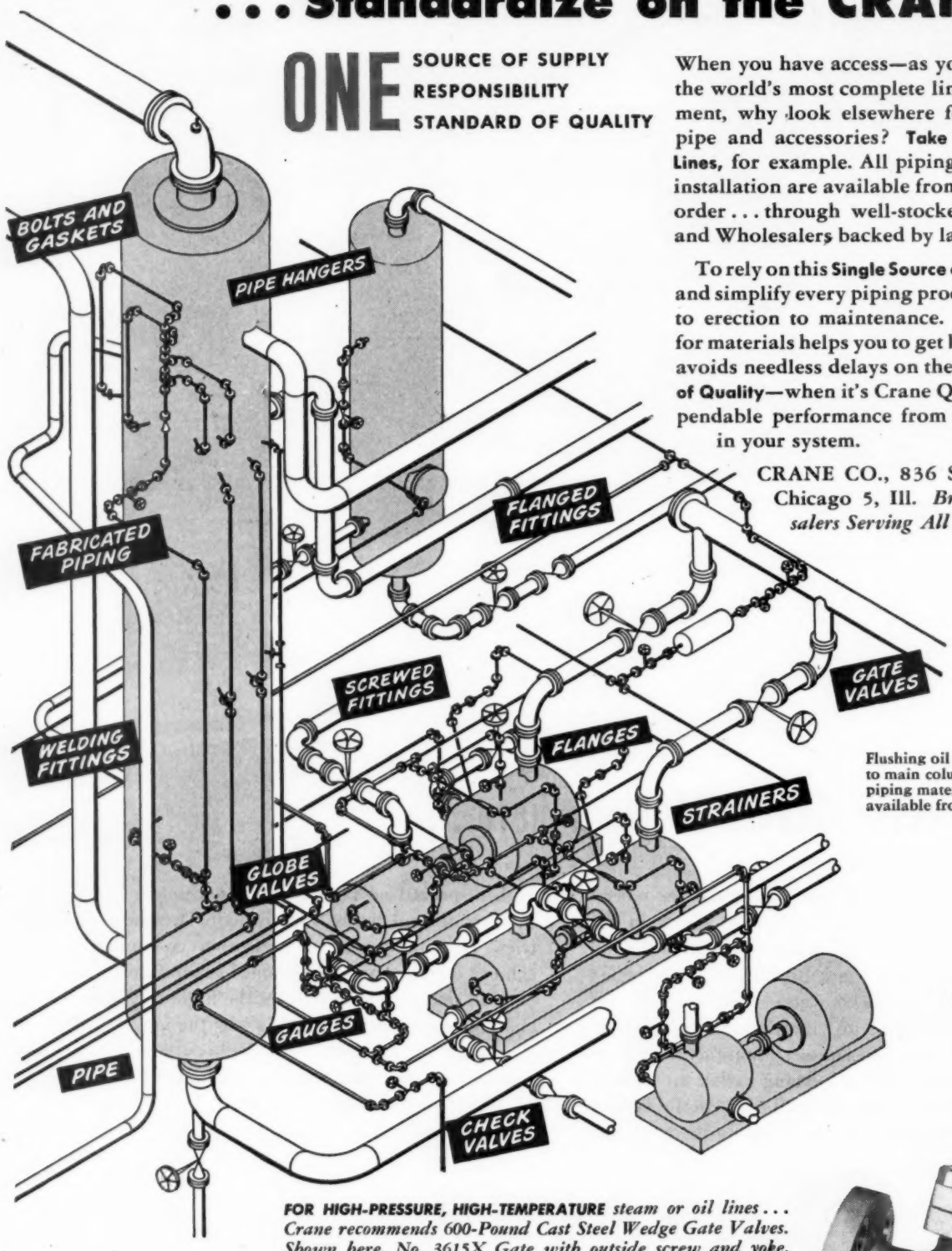
How to simplify piping jobs ... Standardize on the CRANE line

ONE SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY

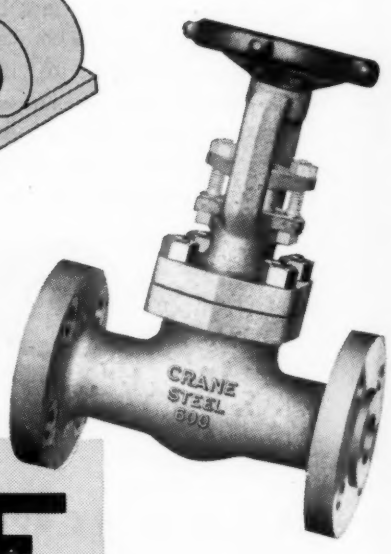
When you have access—as you do at Crane—to the world's most complete line of piping equipment, why look elsewhere for valves, fittings, pipe and accessories? **Take these Flushing Oil Lines,** for example. All piping materials for the installation are available from Crane . . . on one order . . . through well-stocked, local Branches and Wholesalers backed by large factory stocks.

To rely on this **Single Source of Supply** is to speed and simplify every piping procedure from design to erection to maintenance. **One Responsibility** for materials helps you to get better installations, avoids needless delays on the job. **One Standard of Quality**—when it's Crane Quality—assures dependable performance from every piping item in your system.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill. *Branches and Wholesalers Serving All Industrial Areas.*



Flushing oil lines to main column—all piping materials available from Crane.



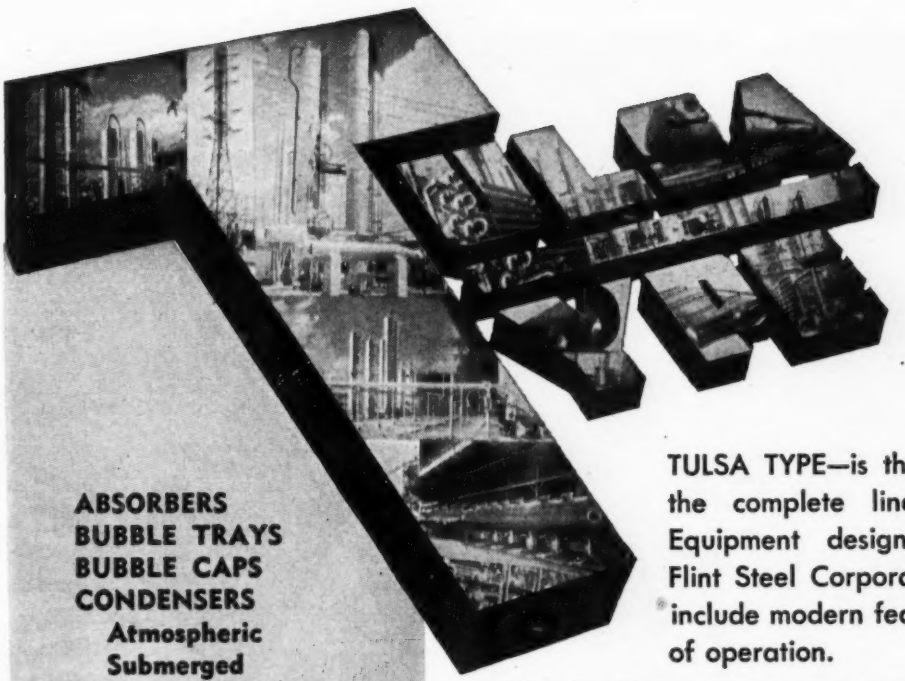
FOR HIGH-PRESSURE, HIGH-TEMPERATURE *steam or oil lines . . . Crane recommends 600-Pound Cast Steel Wedge Gate Valves. Shown here, No. 3615X Gate with outside screw and yoke. Exelloy to Exelloy seating makes these valves ideal for oil and oil vapor services up to 1000 deg. F. Flanged, screwed, or socket-welding ends. Sizes: ½ to 2 in. See your Crane Catalog.*

EVERYTHING FROM . . .

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM



ABSORBERS
BUBBLE TRAYS
BUBBLE CAPS
CONDENSERS
- **Atmospheric**
- **Submerged**

DEPHLEGMATORS
EVAPORATORS
EXTRACTORS-Mist
FABRICATED STEEL
FRACTIONATING COLUMNS
HEAT EXCHANGERS
HEATERS
- **Storage Tank**

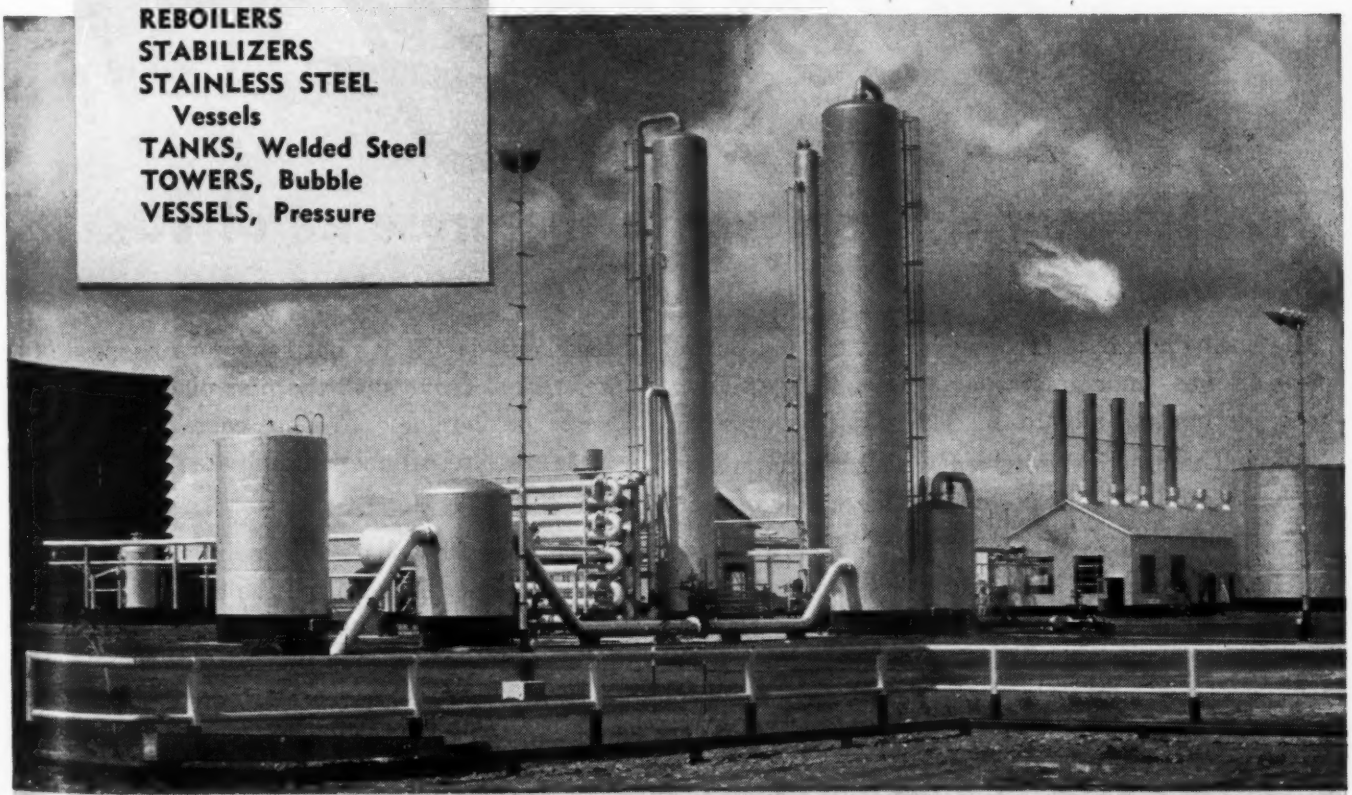
PREHEATERS
REBOILERS
STABILIZERS
STAINLESS STEEL
- **Vessels**

TANKS, Welded Steel
TOWERS, Bubble
VESSELS, Pressure

TULSA TYPE—is the identifying trade mark of the complete line of Petroleum Processing Equipment designed and manufactured by Flint Steel Corporation. All TULSA TYPE Units include modern features of design for efficiency of operation.

TULSA TYPE equipment complies with industry codes such as API-ASME and ASME. During the past years this organization has served as a convenient and reliable source of supply for Gasoline Plants—Oil Refinery Equipment—Structural Steel—Warehouse Steel and Steel Plate Fabrication.

To insure efficient operation, specify TULSA TYPE processing equipment in Cycling Plants, Natural Gasoline Plants, Chemical Plants, Oil Refineries and Gas Transmission Systems.



FLINT STEEL CORPORATION

TULSA, OKLAHOMA, U.S.A.

Export Office: Room 1940, 30 Rockefeller Plaza, New York 20, N. Y.

Selectivity!

Efficient H_2S removal in the presence of CO_2

The Shell Phosphate Process for gas or liquid purification has undergone successive improvements since its unusual advantages were first discovered.

Now it is practicable to remove all but harmless amounts of H_2S in the presence of large volumes of CO_2, while most of the CO_2 is left untouched.

The treating agent is inorganic, low in cost, and is not soluble in hydrocarbons. Since hydrocarbons being treated are not contaminated by the Shell Process treating solution, there are no harmful effects upon subsequent processing.

Regenerated H_2S is relatively pure because of its preferential removal in the first place . . . and because the inorganic treating chemical, having no vapor pressure, cannot contaminate the H_2S released in the stripper.

The Shell Phosphate Process is available to any operator under license from the Shell Development Company, Incorporated . . . together with experienced engineering service for its design, installation, and operation. Write for complete information.

SHELL DEVELOPMENT COMPANY, INCORPORATED

50 West 50th Street, New York 20, N. Y.

SHELL

CUT MAINTENANCE COSTS
in these process groups
with long-life

B&W

Refinery Tubing

Oil Distillation
Thermal Conversion
Gas Conversion
Solvent Refining
Desalting, Filtration, and Acid Treating
Gasoline and Naphtha Treating
Gas Purification
Light Hydrocarbon Recovery and Fractionation
Petrochemical Processes
Catalytic Cracking

A wide choice of analyses for extremes of pressure, temperature, corrosion, and oxidation

Carbon Steel	(½% Mo)
Carbon Moly Steel	(½% Cr, ½% Mo)
Croloy ½	(1¼% Cr, ½% Mo,
Croloy 1¼	(2% Cr, ½% Mo)
Croloy 2	(2¼% Cr, 1% Mo)
Croloy 2¼	(3% Cr, 1% Mo)
Croloy 3-M	(5% Cr, ½% Mo)
Croloy 5	(5% Cr, ½% Mo, 1½% Si)
Croloy 5-Si	(5% Cr, ½% Mo, ½% Ti)
Croloy 5-Ti	
Croloy 7	(7% Cr, ½% Mo,
Croloy 9-M	(9% Cr, 1% Mo)
Croloy 18-8-S	(18% Cr, 8% Ni)
Croloy 16-13-3	(16% Cr, 13% Ni, 3% Mo)
Croloy 25-20	(25% Cr, 20% Ni)

Latest detailed information on all B&W Refinery Tubing is contained in Technical Bulletin 6-E.

B&W SEAMLESS and WELDED TUBES

THE BABCOCK & WILCOX TUBE COMPANY

General Offices: Beaver Falls, Pa. Plants: Alliance, Ohio and Beaver Falls, Pa.

TA-1493-S

One Year . . . Eight Units 76,800 Bbls. Per Day

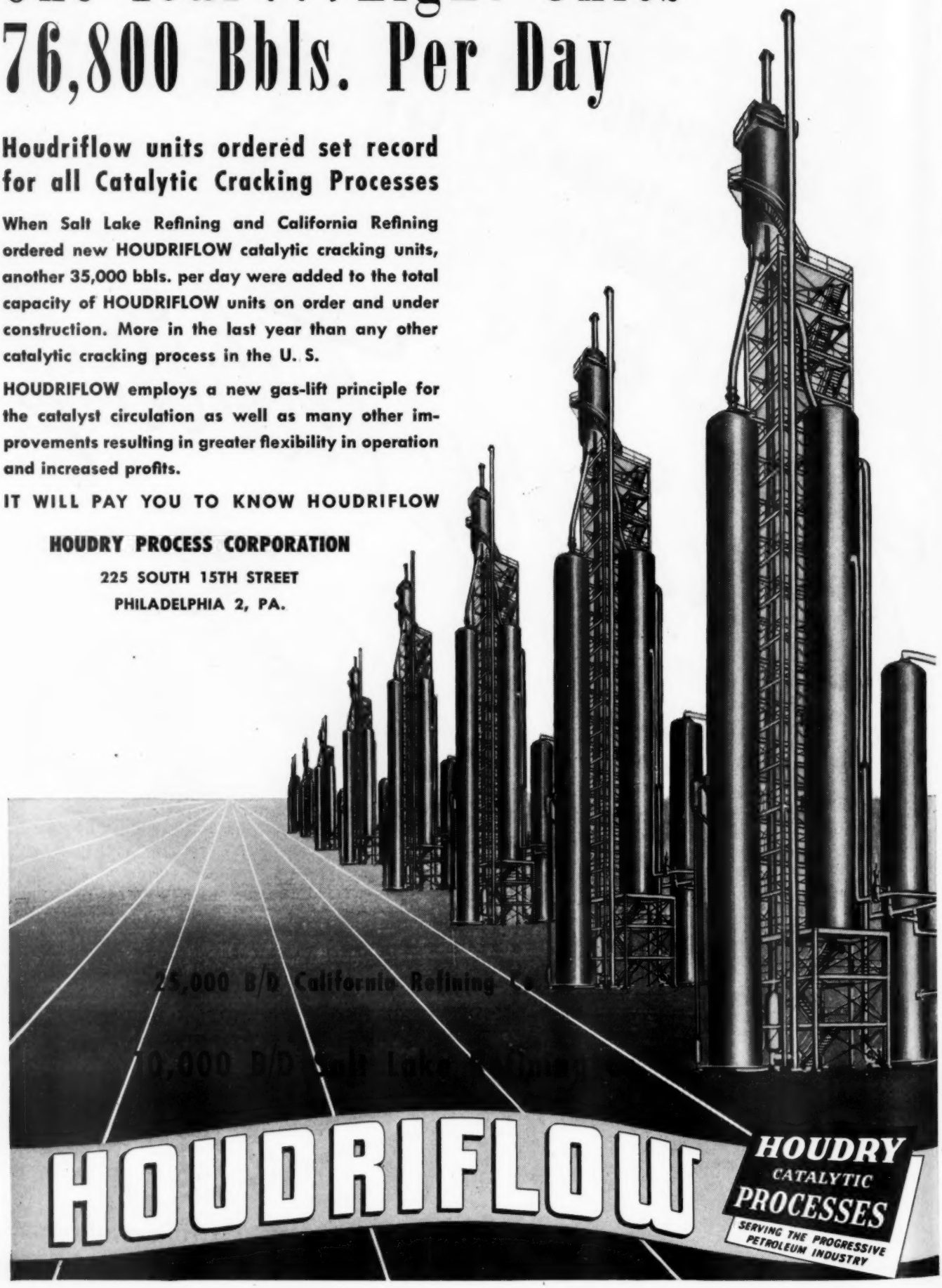
Houdriflow units ordered set record for all Catalytic Cracking Processes

When Salt Lake Refining and California Refining ordered new HOUDRIFLOW catalytic cracking units, another 35,000 bbls. per day were added to the total capacity of HOUDRIFLOW units on order and under construction. More in the last year than any other catalytic cracking process in the U. S.

HOUDRIFLOW employs a new gas-lift principle for the catalyst circulation as well as many other improvements resulting in greater flexibility in operation and increased profits.

IT WILL PAY YOU TO KNOW HOUDRIFLOW

HOUDRY PROCESS CORPORATION
225 SOUTH 15TH STREET
PHILADELPHIA 2, PA.



Where WeldOlet is attached to run pipe, it tapers at proper angles, providing for a single bevel groove joint at the crotch section, blending into a V-butt joint at the ear portion.

The quickest — most economical — way to insure FULL PIPE STRENGTH AT BRANCH CONNECTIONS

WeldOlets*, with outlet sizes from ⅛" to 24", both straight and reducing, need no additional reinforcement to establish and fully maintain original strength on ASTM A-106 Seamless Steel Grade A Pipe, as set forth in Code for Pressure Piping, American Standards Association, B31.1-1942, and Supp. No. 2, B31.1b-1947. WeldOlet welding fittings provide the quickest, most economical, most *satisfactory* method of obtaining *full pipe strength* at branch connections. For detailed engineering reference data, write for Catalog W-2.

BONNEY FORGE & TOOL WORKS

FORGED FITTINGS DIVISION • 368 GREEN STREET • ALLENTOWN, PENNA.

Authorized Canadian Factory Representatives: Sterling Steel Co., Ltd., 20 Temperance St., Toronto 1, Canada—1040 Sherbrook St., W., Montreal, Canada

MANUFACTURERS OF FAMOUS BONNEY TOOLS

Fig. 1—Cut-away view of reducing size WeldOlet with welding outlet in place. The external rib and wide bases or footings of WeldOlets* eliminate the need for *extra supports* to take care of bending or vibrational stresses at crotch section, the point of greatest stress.

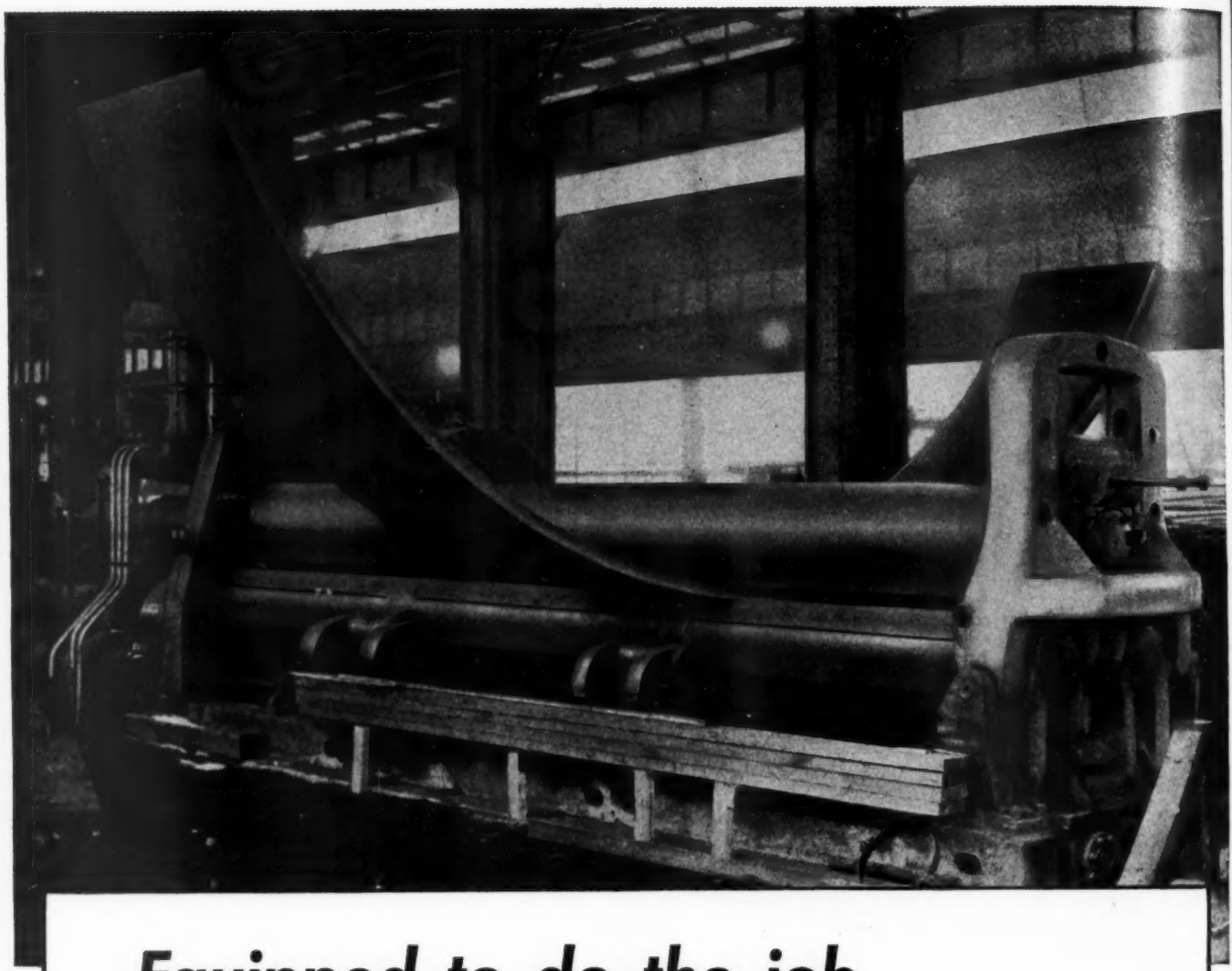
Fig. 2—Note blending of ear portion of welding fitting to run pipe. Extension of weld metal below inside scarfed portion of pipe insures all sections of joint greater than pipe wall thickness.

WELDOLETS

*Trade Mark Reg. U.S. Pat. Off. Pat. in U.S. & Foreign Countries

FOR WELDED BRANCH PIPE OUTLETS

When you want Bonney Welding Outlets, ask for WeldOlets*



Equipped to do the job

Sun builds made-to-order units for all refinery and chemical plant processes. Sun also furnishes repair services and parts. This is evidence of the vastness of Sun facilities, facilities that include rolls so powerful as to be capable of cold bending steel sheets 3½" thick . . . Having similarly extensive facilities for shipbuilding, Sun turns out record-making tankers and cargo vessels from keel to superstructure—no subletting.

Sun

SHIPBUILDING & DRY DOCK COMPANY

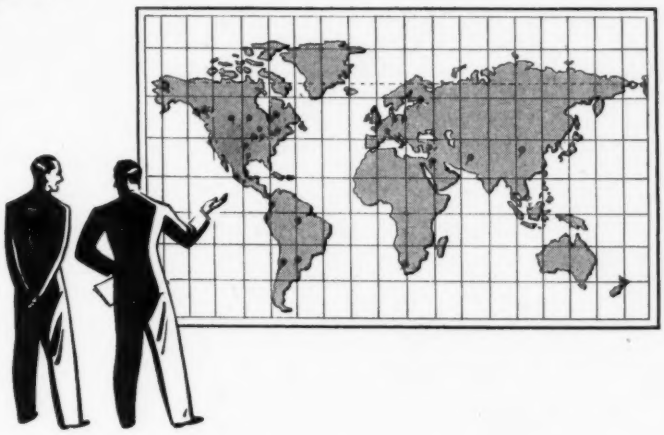
SINCE 1916

ON THE DELAWARE • CHESTER, PA.

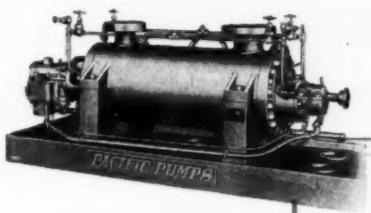
25 BROADWAY • NEW YORK CITY

FOR THE BEST IN PRODUCTS AND SERVICE

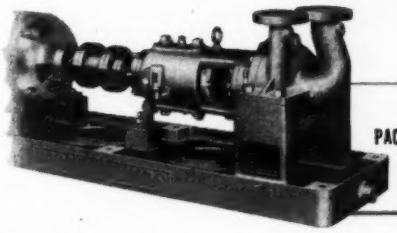
Engineers the World over specify PACIFIC *Precision Built* PUMPS



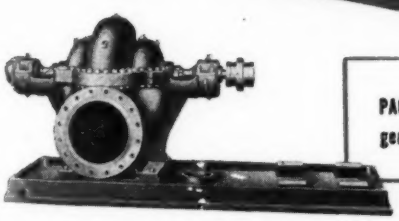
Engineered to the service requirements
Hydraulically designed for sustained efficiency
Mechanically designed for endurance and simplicity



PACIFIC TYPE **I**
hot charge pump



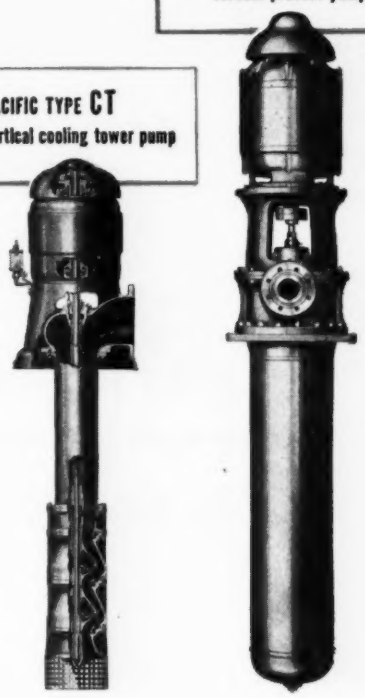
PACIFIC TYPE **SVC**
process pump



PACIFIC TYPE **DC**
general service pump

PACIFIC TYPE **WY**
vertical process pump

PACIFIC TYPE **CT**
vertical cooling tower pump



Pacific builds a complete line of Vertical and Horizontal Single and Multi-stage Pumps in all capacities, pressures and temperatures

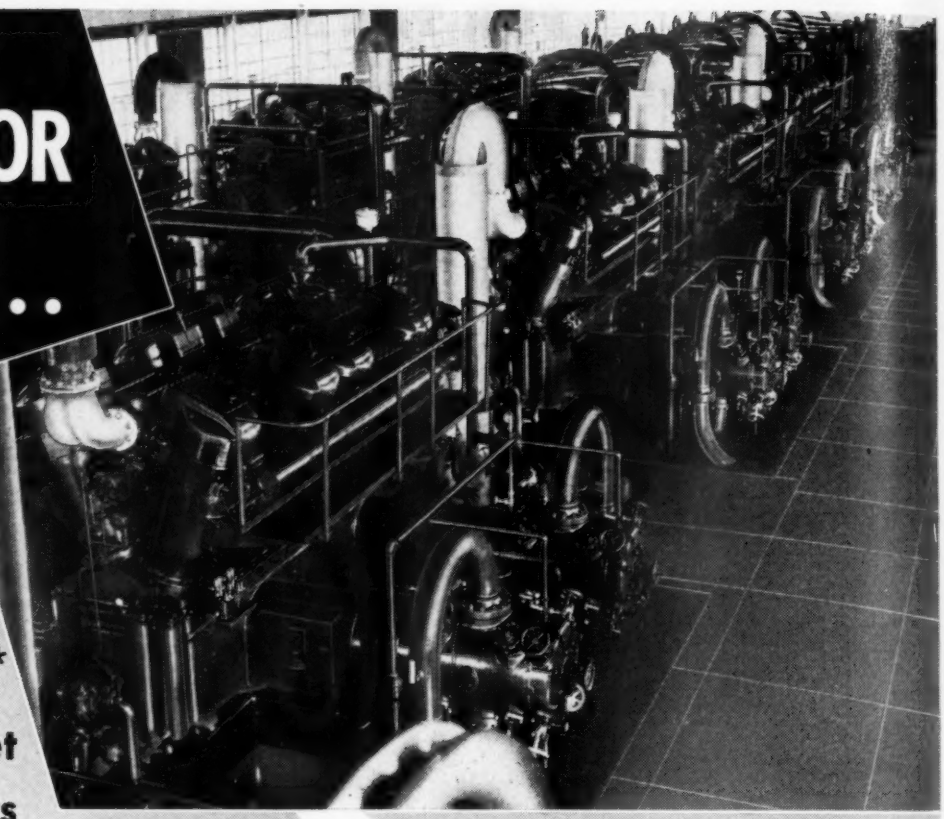
25th ANNIVERSARY

PACIFIC *Precision Built* **PUMPS**

PACIFIC PUMPS INC. HUNTINGTON PARK, CALIFORNIA
One of the Dresser Industries
Export Office: Chanin Bldg., 122 E 42nd St., New York
Offices in All Principal Cities

C-1

COMPRESSOR STATIONS...



...Another of

PRITCHARD'S GAS ENGINEERING* Services That Meet Your Requirements

for

UNDIVIDED RESPONSIBILITY

PRITCHARD's SINGLE RESPONSIBILITY CONTRACT *includes...*

- Analysis of Requirements
- Design
- Engineering
- Field Construction
- Purchasing
- Guarantees
- Operating Tests
- Firm prices quoted on a "Turnkey" Basis

***These Pritchard GAS ENGINEERING Services Are Available to You...**

- Compressor stations and additions
- Pressure maintenance units
- Desulphurization, amine type
- Conditioning and treating
- L.P.G. installations
- Cooling and heat transfer
- Removal of liquids and dust
- Gasoline plants

Your inquiry is invited.

THREE FUNCTIONS — Engineering, Construction, Manufacturing

IN FIVE FIELDS — Serving the CHEMICAL, POWER, PETROLEUM and GAS industries as well as providing specialized EQUIPMENT for all industries.

NATIONAL CONSTRUCTORS ASSOCIATION — OIL, STEEL, CHEMICAL — MEMBER

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NATURAL GAS DIVISION

J.F. Pritchard & Co.

ENGINEERS • CONSTRUCTORS • MANUFACTURERS

908 GRAND AVE., KANSAS CITY 6, MISSOURI

NEW YORK • CHICAGO • LOS ANGELES • HOUSTON • PITTSBURGH • ST. LOUIS • TULSA

Not Just "LOW-PRESSURE COMPRESSORS"

Two Worthington horizontal duplex opposed steam-driven RDV pumps (Type ODV) in the lubricating oil treating plant of a large refinery.

...but SPECIALIZED VACUUM PUMPS

Modern refinery practice demands the utmost efficiency in processing. And this efficiency can only be obtained with equipment that's *specifically designed for the job!* That's why, in refineries all over the world, WORTHINGTON is the top name in vacuum pumps.

These close clearance, high vacuum units are built with precision . . . Feather* Valves with hardened alloy seats and guards are the most efficient "breathers" made . . . extreme simplicity of construction gives unusual accessibility . . . top-grade materials insure greater ruggedness . . . conservative ratings give you abundant reserve power. No wonder, then, that in modern solvent extraction and solvent dewaxing plants WORTHINGTON vacuum pumps are the industry's first choice.

GET ALL THE FACTS

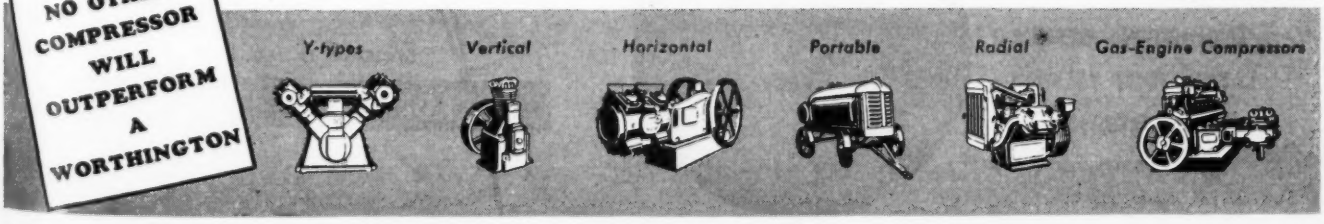
Worthington Horizontal Dry Vacuum Pumps are available in a variety of designs and drives permitting selection of the *right* unit to maintain the required vacuum at lowest operating cost. Bulletin L-710-B1B contains further facts proving *there's more worth in Worthington.* Write to *Worthington Pump and Machinery Corporation, Compressor Division, Buffalo, N. Y.*

WORTHINGTON

K.8.9

*Reg. U. S. Pat. Off.

NO OTHER COMPRESSOR WILL OUTPERFORM A WORTHINGTON



CONTINUOUS REFINERY OPERATION IS MORE PROFITABLE

MORE TIME ON STREAM
OPERATIONS ACCORDING TO PLAN
FEWER UNSCHEDULED SHUT DOWNS
REDUCED REPAIR AND MAINTENANCE COSTS
these advantages all add up to
CONTINUOUS OPERATIONS
Assure them for your refinery—

SPECIFY

TRET-O-LITE

CHEMICAL DESALTING

...helps refiners to maintain a continuous schedule of operations by preventing frequent shut-downs due to salt plugging and hard coking, and by helping to curtail corrosion damage. Many leading refiners rely on Tret-O-lite for efficient salt removal—for complete information, write or call

COMPLETE DESALTING
Service
ENGINEERING DESIGN
LABORATORY TESTING
CONSULTATION

TRETOLITE COMPANY

Manufacturing Chemists
ST. LOUIS 19, MISSOURI

DESALTING | DEHYDRATING

DUPONT TETRAETHYL LEAD COMPOUNDS

Du Pont

Field Laboratories . . . At Work to Help the Refiner

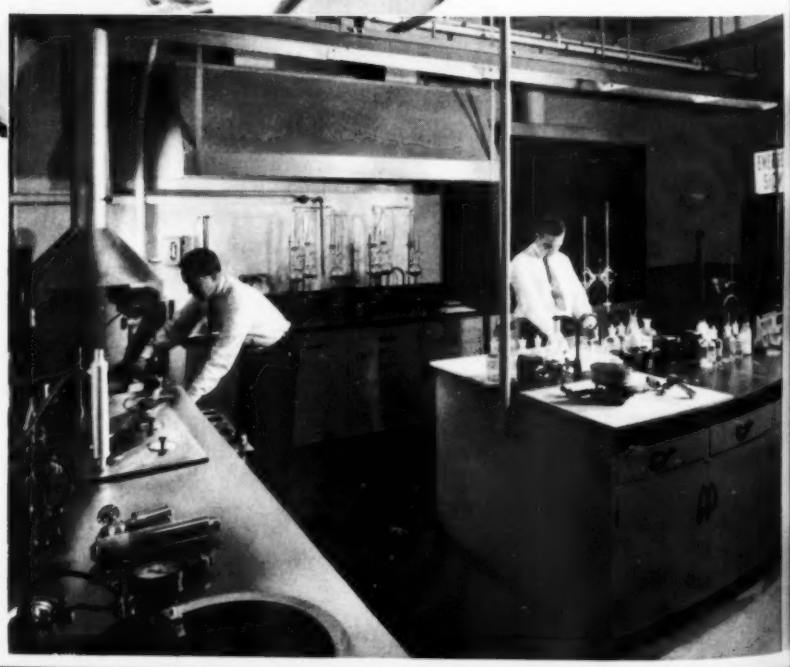
Five Du Pont Field Laboratories, located in the major refining centers, are providing many diversified services to help the refiner in the solution of specific problems. These laboratories are completely equipped and staffed with experienced personnel. They perform the many tests essential to the efficient and safe use of TEL compounds and other additives; in addition, the scope of their work covers a far wider range of activities such as advice and aid on laboratory, as well as plant problems connected with the use of additives. As a result, many refiners are finding that their helpful assistance and recommendations are enabling them to produce better fuels . . . more economically. If you haven't already done so, avail yourself of this useful service.

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living
. . . Through Chemistry

A complete line of g

Sulfur determination is only one of many standard A.S.T.M. tests which the District Laboratories are equipped to run.



The inspection section of each field laboratory has the latest and most modern equipment for helping on problems dealing with the use of Du Pont TEL compounds and other additives.

Each
with
and fo
chemi
plies
tetrae
omme
ments
Lab
demo
tories
faced

gasoline additives...

PLUS...

A Complete Laboratory Service

Help You Meet Your Fuel Requirements . . .

Efficiently . . . Economically

Each Du Pont District Laboratory is a complete unit with full facilities for determining lead susceptibility and for making knock tests on motor gasoline as well as chemical analyses. This, and the fact that Du Pont supplies a complete line of gasoline additives including tetraethyl lead compounds, enables them to make recommendations covering the entire additive requirements of fuel.

Laboratory records show numerous case histories that demonstrate the type of help Du Pont District Laboratories are providing. For example; several refiners were faced with meeting rigid octane specifications. The Du Pont laboratory serving that area ran lead susceptibility tests on many combinations of blending stocks including iso-pentane blends. From the information developed through these tests, the refiners were enabled to meet competitive octane specifications. In another case a suggested change in processing sequence and the addition of antioxidant at an earlier stage led to improved gasoline storage stability.

Instance after instance proves that the helpful cooperation of Du Pont District Laboratories is aiding refiners in the solution of many problems related to additive usage and gasoline refining.

The knock testing section renders many helpful services in connection with determining lead susceptibility of stocks and checking octane number of refiner's blends.

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING...*Through Chemistry*

Du Pont Laboratories Provide Nationwide Check

Of Gasoline Octane Ratings and TEL Content

As a marketing information service to refiners, Du Pont District Laboratories periodically obtain and check filling-station samples of gasolines sold in their area. These fuels, both premium and regular, are tested in the laboratory to determine the octane number, both motor and research, as well as the amount of TEL per gallon.

These reports on individual gasolines are coded and listed so that the interested refiner can check his fuels not only against averages but against individual fuels. These valuable reports are made every three months. This is another example of the helpful services provided by Du Pont Research Laboratories . . . to help the refiner meet specific marketing requirements.

Tetraethyl lead analyses are run by each District Laboratory as part of their service to refiners in the area.

DU PONT

PETROLEUM CHEMICALS DIVISION
MOTOR GASOLINE SURVEY

CITY	CODE NO.	PREMIUM			REGULAR			DATE SAMPLED
		OCTANE NO.		TEL CC/GAL.	OCTANE NO.		TEL CC/GAL.	
		MOTOR	RES.		MOTOR	RES.		
New York, N. Y. (Metropolitan Area)	34	80.9	88.4	2.40	79.4	86.6	2.65	9-26
	47	81.7	89.8	2.53	80.5	85.2	2.64	"
	50	80.8	91.7	0.96	76.0	83.6	0.29	"
	56	80.9	88.2	1.36	80.1	85.0	1.29	"
	61	83.2	88.7	1.79	76.3	83.0	1.34	"
	64	81.3	89.2	1.81	79.0	83.1	1.70	"
	71	82.1	88.7	1.36	80.4	83.4	1.42	"
	72				76.6	84.4	Nil	"
Average		81.6	89.2	1.74	78.5	84.3	1.42	
Philadelphia, Pa.	34	77.7	86.0	1.09	76.0	82.5	1.12	9-27
	37	80.0	89.7	1.22	75.9	83.3	0.70	9-23

MAKE DU PONT THE SOURCE FOR ALL OF YOUR GASOLINE ADDITIVES . . .

Tetraethyl Lead Compounds
(Motor Mix—Aviation Mix)
Antioxidants
Metal Deactivator—Dyes

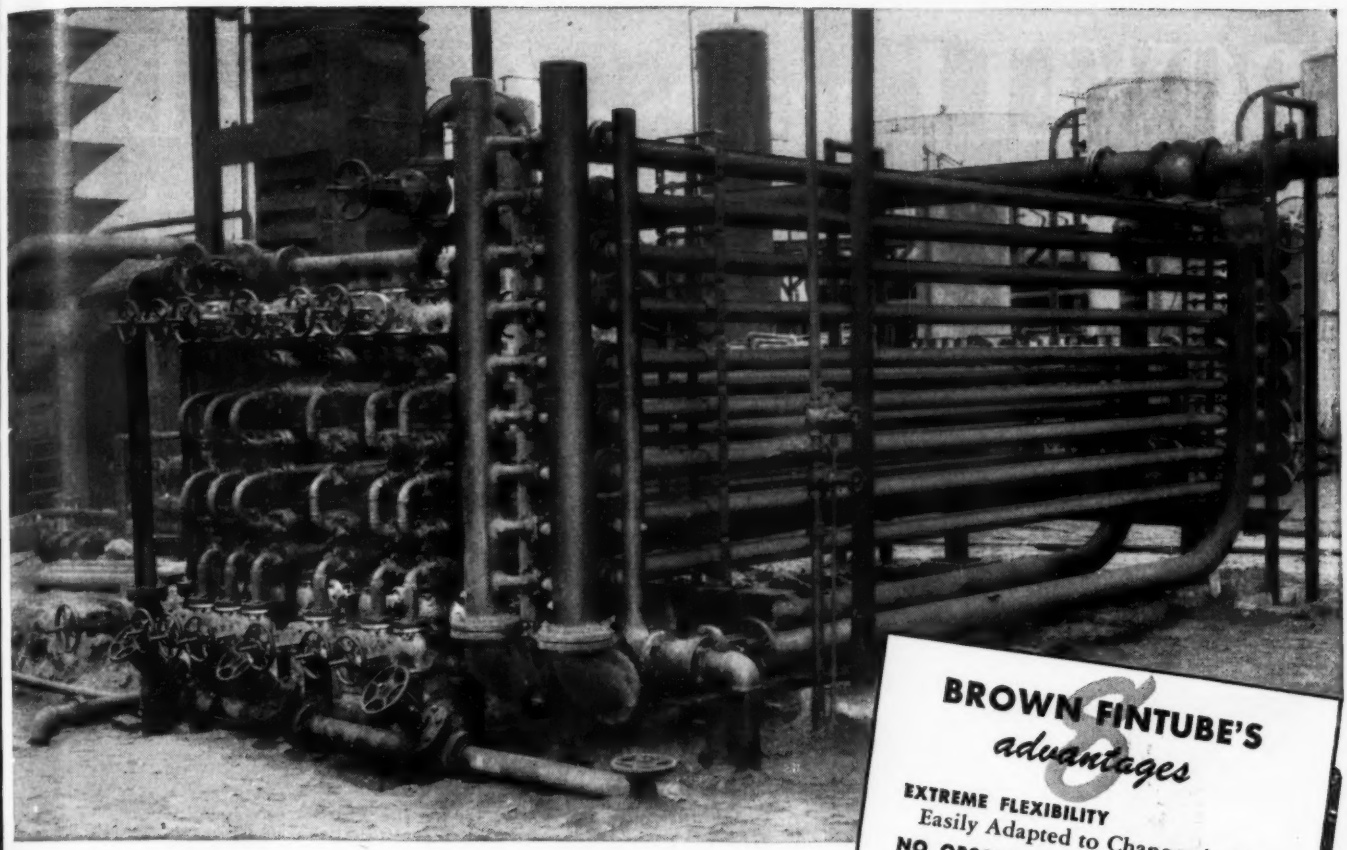
DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING...*Through Chemistry*

E. I. DU PONT DE NEMOURS & COMPANY (INC.)
PETROLEUM CHEMICALS DIVISION
Wilmington 98, Delaware

District Laboratories: Wilmington, Del. · Chicago, Ill. · Tulsa, Okla. · Houston, Texas · El Monte, Calif.

District Offices: Wilmington, Del. · Chicago, Ill. · Tulsa, Okla. · Houston, Texas · Los Angeles, Calif.



continuous operation

Brown Fintube Sectional Exchangers Eliminate Shut-downs for Cleaning Pay Users Extra Dividends

● By simply manifolding an extra parallel stream into the bank, one stream after another can be taken off-line and cleaned, while the exchanger operates at full capacity.

This avoids the necessity of carrying a 100% standby unit to insure continuous operation. It permits the sections to be cleaned as frequently as the duty requires, without effecting other parts of the plant, and assures *clean surfaces* and *efficient* operation, year after year, without shut-down.

For the utmost in efficiency and economy — use Brown's proven, welded fintube heat exchangers throughout your plant. Estimates and quotations furnished promptly. *Write for Bulletin No. 481.*

BROWN FINTUBE'S *advantages*

EXTREME FLEXIBILITY
Easily Adapted to Changes in Duty

NO OBSOLESCENCE
Avoiding Waste and Expense

FLANGED HEAD END ASSEMBLY
Eliminating Ground Joint Seals

EASY MAINTENANCE
Using Only Common Tools

CONTINUOUS OPERATION
No Shut-Downs For Cleaning

REDUCED STORES REQUIREMENT
Minimizing Investment and Handling

QUICK DELIVERY
Only a Few Hours in Emergency

INCREASED CORROSION ALLOWANCE
Longer Tube Life

THE BROWN FINTUBE CO.
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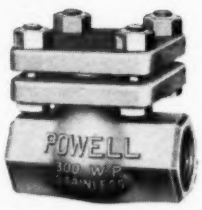

Fig. 2004—300-pound Stainless Steel Lift Check Valve with bolted cap.

Fig. 3053—Class 300-pound Cast Steel Angle Valve with a top-mounted, fully enclosed explosion proof electric motor operator for quick positive opening and closing.

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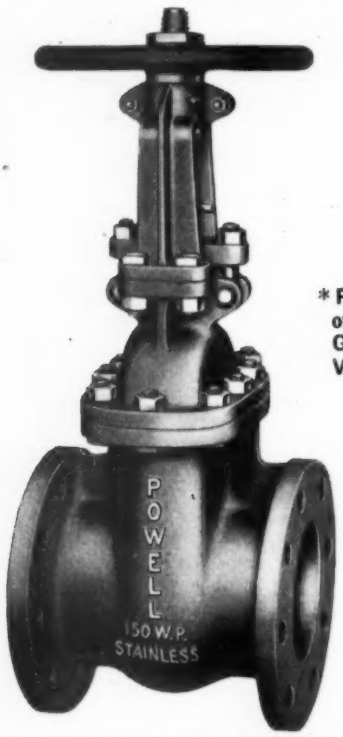

Fig. 2453-G—Large 150-pound Stainless Steel Gate Valve with bolted flanged yoke-bonnet, outside screw rising stem and tapered solid wedge. Made in sizes 5" to 30", inclusive.

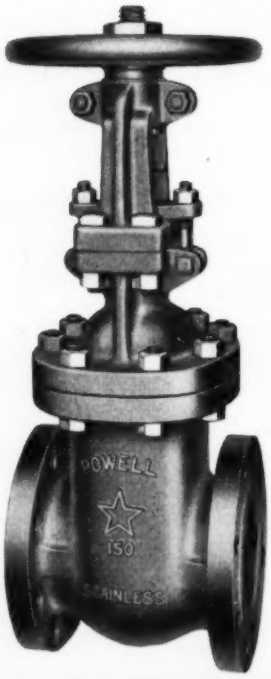

Fig. 1503 S. S.—Class 150-pound Stainless Steel Gate Valve with flanged ends, outside screw rising stem, bolted flanged yoke and tapered solid wedge.

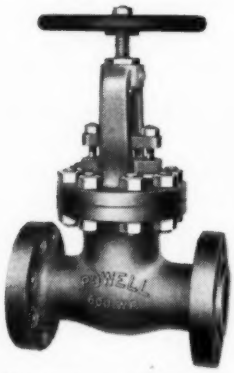

Fig. 1973—Small 600-pound Stainless Steel Gate Valve with flanged ends, outside screw rising stem, bolted flanged yoke, tapered solid wedge. Sizes ½" to 2", incl.

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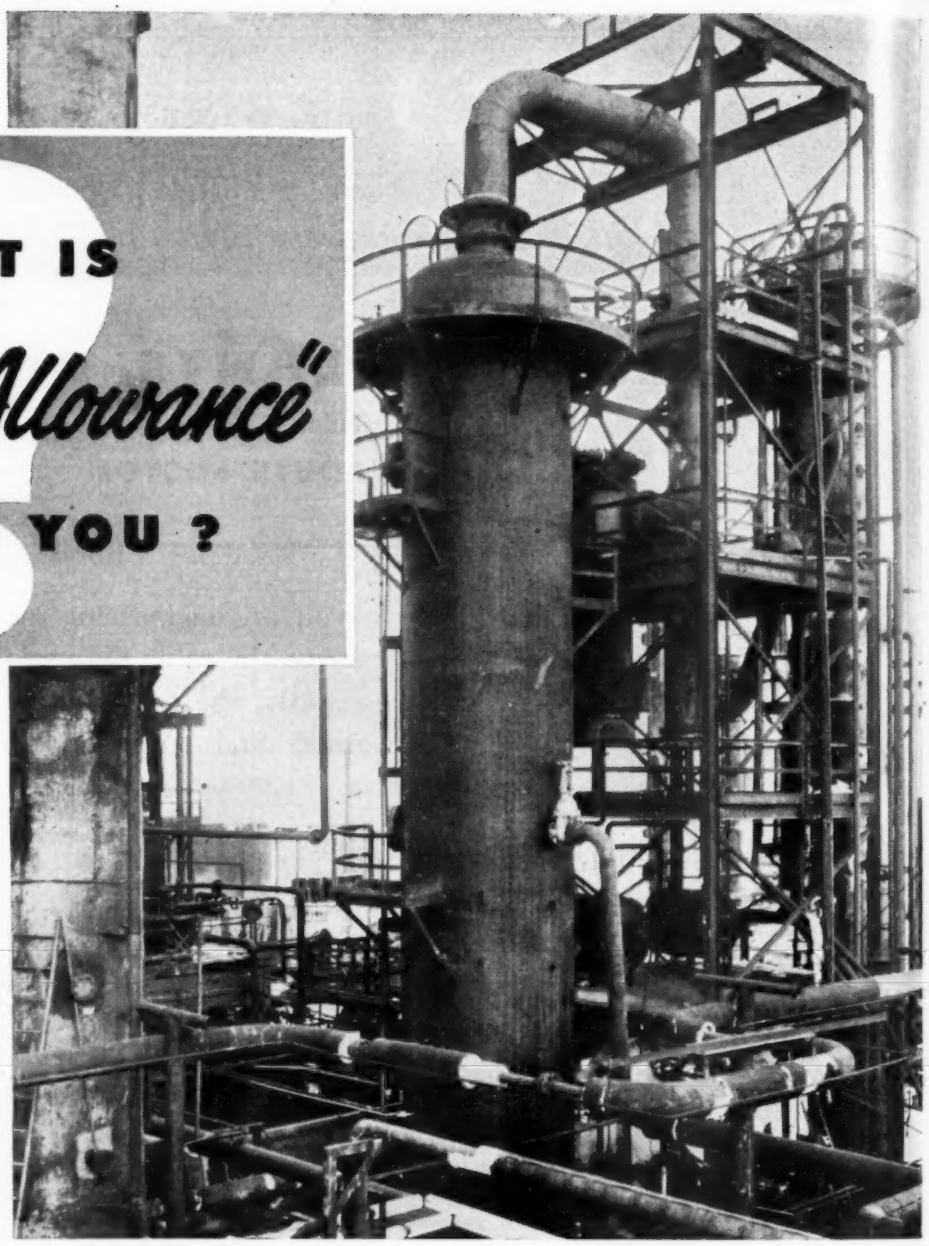
Oil and Gas Department

CHEMICAL PLANTS DIVISION

BLAW-KNOX CONSTRUCTION COMPANY

Tulsa, Oklahoma **Pittsburgh, Pennsylvania**

WHAT IS "Corrosion Allowance" COSTING YOU ?



The full thickness of the Lukens Stainless-Clad Steel in this vacuum tower carries its share of structural loads. Fabricated by The Lang Company, Inc., Salt Lake City, Utah.

If you're building steel equipment *extra-thick* to compensate for the material's high corrosion rate, consider using a Lukens Clad Steel and save money on corrosion allowance.

The ASME Boiler Code permits the designer to employ the full thickness of these corrosion-resistant materials for calculating required thickness in design.

Clad construction thus offers many advantages. It is lighter because of minimizing corrosion allowance. Less weight means cheaper construction costs, less freight. High pressures and production rates can be maintained; no danger of failures from rust-weakened equipment. Heat transfer properties are usually better through thinner walls.

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Bulletin 449 shows how other companies are using Lukens Clad Steels to advantage. For a copy, and for engineering help, write Lukens Steel Company, 443 Lukens Building, Coatesville, Penna.

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SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

A Token of PROGRESS

PROGRESS has three meanings, according to Webster. Growth. Movement forward. Improvement.

We have just observed Oil Progress Week, dedicated to the year's accomplishments of the Petroleum Industry. Cities Service contributes to the celebration an expression of confidence in the industry's future, and a record born of that confidence.

For example, Cities Service completed during the year 1949 three major projects

—a $20,000,000 expansion of its East Chicago refinery.

—a $30,000,000 26-inch gas pipe line from the Hugoton field in Kansas to Kansas City.

—a $42,000,000 lube plant, the most modern in the world, at Lake Charles, Louisiana.

This expenditure of nearly $100,000,000 is progress by growth and movement. It is also progress by improvement . . . of processes and products.

For example, the lube plant puts into practice the knowledge of a life-time study of combustion. Cities Service, between 1929 and 1949, analyzed the combustion of ten million vehicles. In the nine days preceding Pearl Harbor it analyzed 24,409 motors for the Office of Civilian Defense.

Cities Service has a first-hand knowledge of what is expected of a motor oil today.

To live up to the "improvement" definition of progress, Cities Service engineers and researchers, working together, are making available daily from this new plant 6000 barrels of lubricating oils designed to meet the many varied needs of this modern age of wheels.

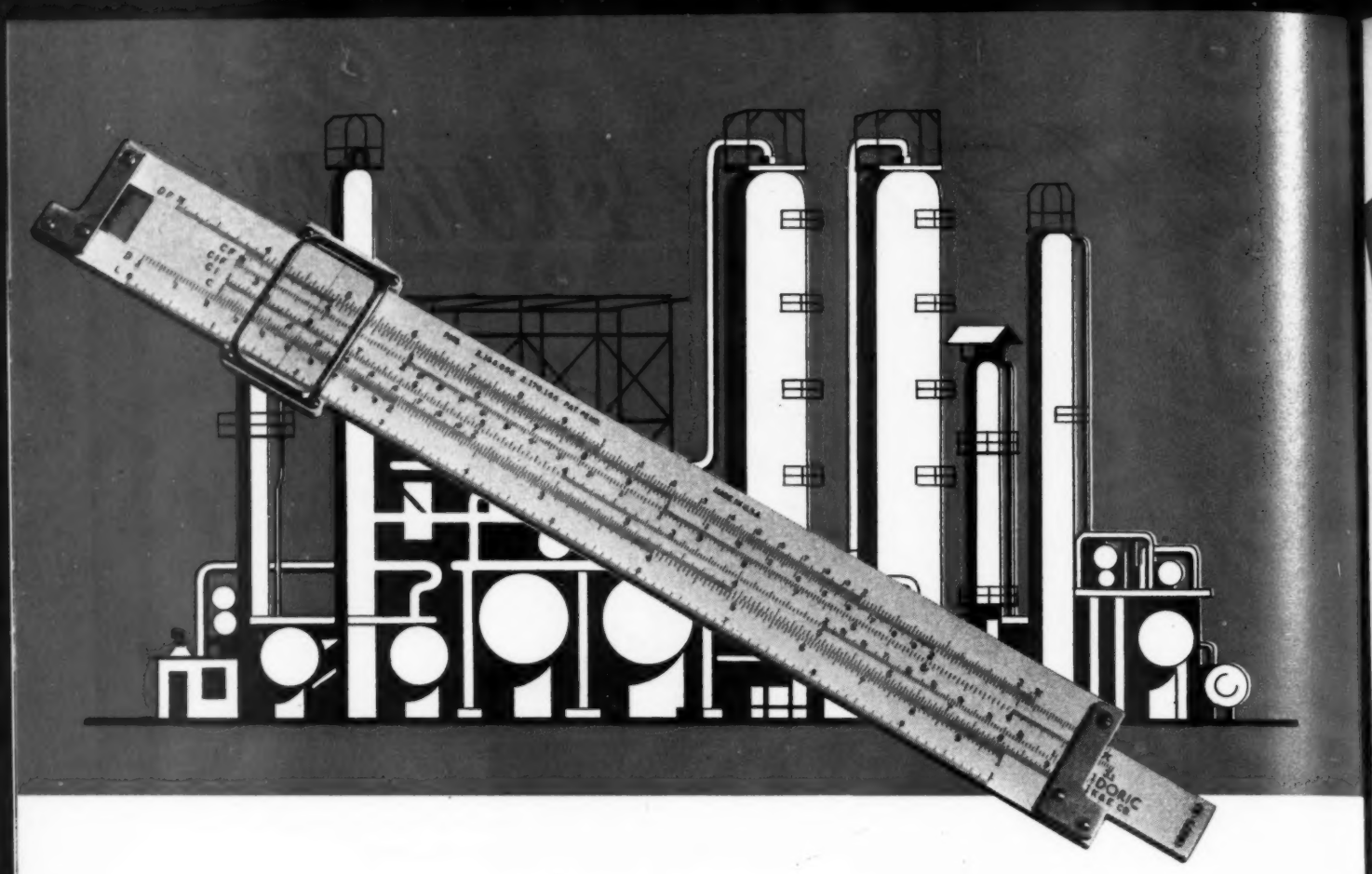
The national welfare requires quality products today as never before. The temperatures, pressures and speeds of America's industrial engines and war machines are increasing almost by the hour. This calls for better grade oils, the finest oils that can be produced. The demand for super-lubricants is imperative, and for thousands of tons per year. The new Lake Charles plant stands ready to meet this demand in both quantity and quality.

We feel it is fitting to chronicle these activities, because, after all, the progress of an industry is but the sum total of its component parts.

Progress through Service has been the motto hanging on our wall from the beginning. It is something more than a motto. Customers who bought $600,000,000 of our goods last year testify that service, as practiced by this Company, is in assisting users to get more out of petroleum products than they would otherwise obtain.

CITIES SERVICE

Progress through Service



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SOUND, ECONOMICAL REFINERY ENGINEERING

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1 Sound, efficient refinery engineering backed by many years of successful, world-wide experience.

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3 Rapid, *low-cost* construction by efficient field crews experienced in working together as one organization.

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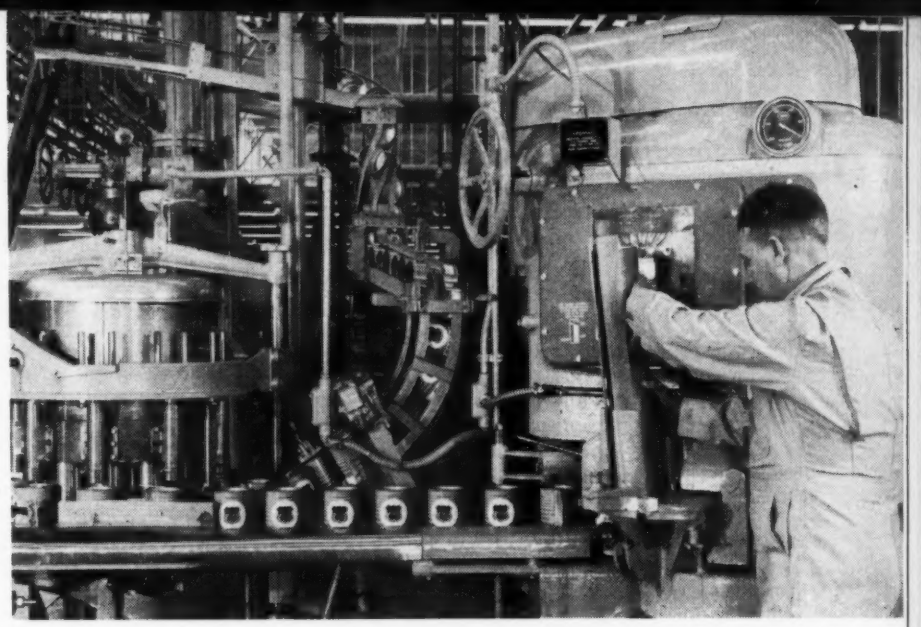


Phillips Oil Co.'s automatic canning at rate of 575 quarts per minute

STREAMLINED LUBE PLANT

By D. P. THORNTON, Jr.
Southwestern Editor

COMPACT design, streamlined flow of materials and unique process combinations feature the new solvent lubricating oil plant of Phillips Petroleum Co., at its Kansas City refinery. Operational flexibility is achieved and storage requirements are reduced, among other advantages. A continuous lube blending plant combines the base stocks with additives in a single, largely automatic operation from refinery storage to can, drum or tank car.

Designers had several things in mind when laying out this plant, which has a designed capacity of 1500 BPCD of finished lubricating oils. First were product quality and yields, which dictated employment of solvent extraction methods and the avoidance of thermal decomposition during processing. Clay finishing was to be carried out at low temperatures to avoid cracking and possible deterioration of the oil. Next, processing to yield a "good" color was desired, not because it is indicative of quality, but many buyers still are "color-conscious." A flexible plant was required to meet changing market conditions and production at will of premium, heavy duty and competitive or "housebrand" grades.

The existing lubricating oil facilities at the Okmulgee, Okla., refinery were outmoded and too small. Consequently it was decided to combine all lube manufacturing operations in a larger refinery, geographically located closer to the center of Phillips' marketing territories. Idle equipment which could be utilized was available at Kansas City. M. W. Kellogg Co. designed and constructed the lubricating oil refining units in cooperation with Phillips engineering staff under the technical direction of R. W. Henry. The Phillips company designed and built the compounding plant.

The processing operations selected were vacuum distillation to split neutral oils from cylinder stock, propane fractionation to segregate two grades of bright stock and deasphalt the heavy bright and for all stocks phenol solvent extraction, followed by propane dewaxing and clay finishing. This report will be concerned with departures from the conventional in plant operations. For basic process techniques and reader is referred to the many excellent descriptions which have been published in the past few years.

Four Stocks Produced

The first operation is two-stage vacuum distillation at low temperature. A topped blend of Oklahoma crudes is heated to 680° F. in an all-radiant section, Kellogg A-frame, bottom-fired heater and charged to the first stage of vacuum distillation under an absolute pressure of 35 mm. of mercury. SAE 10 and 20 weight stock, plus heavy gas oil, are taken overhead in this tower while the heavy oils and tars are charged to propane fractionation.

The overhead again is heated in a smaller furnace to 600° F. and enters the second vacuum still where an absolute pressure of 70 mm. Hg prevails. This column takes heavy gas oil overhead for return to the basic refinery, a light neutral oil corresponding to SAE 10 weight as a side-stream, and makes a bottom product of SAE 20 stock. The oil streams are carefully steam-stripped to provide narrow boiling range fractions and stored for further processing. Fischer and Porter "Viscorators" have been adapted to control product viscosity off these columns.

By this arrangement, it will be noted, the stocks are not heated to levels where thermal cracking could be expected to occur. Heater interiors always are black. The literature contains many references to the effect that taking an SAE 30 or heavier stock overhead in vacuum distillation may result in some cracking. With this view designers of the Phillips plant apparently concur and the separation of SAE 50 weight oil from heavier stocks is reserved for low-temperature fractionation with propane in combination with propane deasphalting.

The installation of 2-stage tower propane fractionation at Kansas City is said to be the first commercial unit of its type.

Heavy bottoms from the first vacuum distillation are cooled and at some 700 psi. enter the first propane fractionation column. There are two ways in which this operation is performed, using two columns, as diagramed in Fig. 1 (Phillips may later add a third column, to provide for still closer fractionation and the production of a still heavier weight base stock). In Method A, heavy asphalt and tar bottoms are produced on the first tower, taking all lube grade stock overhead, and obtaining the split between the medium heavy oil, corresponding to SAE 50 weight, and a heavy bright stock of about 210 Saybolt viscosity at 210° F. in the second column. Phillips uses the alternative Method B to produce these

two stocks, taking the medium heavy bright as overhead product in the first column and making the split between the heavy bright and tar-asphalt in the second column.

Taking the desired products overhead, rather than one as a bottom product as in the other method, gives a product freer of contamination by asphaltic materials, Phillips engineers believe. This is demonstrated under present operation by color of the propane-free fractionated stocks, which test between 4 and 4½ NPA for the SAE 50 weight oil and 6 to 7 for the heavy bright before further processing. The light colors indicate the stocks are substantially free of color-bodies, which have been carried down into the asphalt-tar bottoms off the last tower.

Temperature control and propane: oil ratio are the essence of satisfactory operation of these columns, since the desired separations depend entirely on the differential solubilities of the various viscosity grades in propane. Conditions are so chosen that propane will not tend to vaporize and operation near the critical point for propane is avoided. Temperature control is maintained by thermocouples actuating inlet valves to steam coils in the tops of the towers. In the first column the top temperature is 195° F., bottom 170° F., pressure 700 psi.; in the second, top temperature is 160°, bottom 130°, pressure 500 psi. Following fractionation the stocks are freed of propane by flashing and steam stripping.

Propane Recovery System

Although conventional in many respects, the propane recovery step achieves 95% recovery without recourse to compression. This procedure likewise is employed in recovering propane from the dewaxing step later. In the dewaxing step the oil-propane solution is first flashed at 285 psi., using a vessel heated with 225 psig. steam coils. In a second, similarly heated vessel, the stock is again flashed at 250 psi., the vapors joining the original flashed vapors for total condensation with 85° F. cooling water to enter propane storage maintained at 210 psi. This is illustrated in Fig. 2. In the propane heavy oil fractionating unit, the flashing pressures are still higher, and three high-pressure stages are used: 1st. flash at 595 psi, 2nd. flash at 580 psi, 3rd. flash at 385 psi.

The stock is finally stripped and flashed in a vessel at 5 psig., using 55-lb. plant steam for stripping. The effluent vapors are water scrubbed, then compressed to 250 psi., cooled and stored. The oil goes to intermediate storage for further processing. Propane storage consists of three vertical vessels, Fig. 3, which formerly were used as reactors in the refinery's now-dismantled butane isomerization unit, and this storage supplies all propane used in fractionation and dewaxing.

One of the problems associated with handling of propane in quantities required for heavy lube fractionation and dewaxing is the question of leaks. Reda deepwell pumps are used at Kansas City. The deepwell design was chosen because there are no stuffing boxes to leak since the driving motor is sealed within the the liquid stream itself.

From this point on, lube stock flows are not continuous. Instead, each of the four primary stocks is stored, to await its turn for individual processing through the remaining steps of phenol extraction, propane dewaxing and clay finishing. The refinery does not at present finish its waxes and could, if crude wax market conditions warrant, use the unfinished wax as a catalytic cracking stock.

Principal reason for the preparation of four narrow-cut lube stocks is to permit the optimum degree of refining for each and this, in turn, was partly responsible for selection of the methods of fractionation, according to Phillips' engineers. Propane tower fractionation seemed the best way to separate the heavy lube stocks without danger of thermal decomposition.

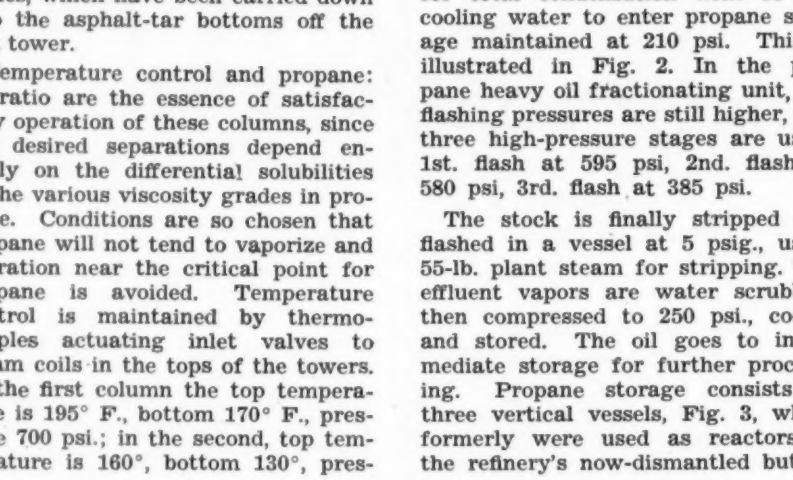
Propane dewaxing was a logical choice, since propane handling equipment would be needed anyway, and because this single solvent could be used on the full range of differing viscosity stocks without complications in adjusting components of the solvent. Phenol extraction works well with propane fractionated stocks, and because it too employs but a single solvent, this method was selected for viscosity-index improvement.

Phenol Extraction

The use of narrow-cut stocks in solvent extraction improves the yield of quality oil. If a stock having a wide boiling range is solvent extracted, the lighter portion of each fraction is necessarily over-extracted in order to sufficiently refine the heavier portions of that fraction. Over-extraction removes desirable hydrocarbons which tend to inhibit oxidation in service, thereby lowering the yield and increasing additive requirements. By treating narrow boiling-range fractions to the optimum degree for each, then blending any desired combinations of refined oil stocks, inherently more stable and serviceable mineral oil products are secured.

The phenol extraction unit is largely standard except for special provisions for heat economy in stripping and the use of more than usual number of extraction trays in the treating tower. The stocks are re-

This Month's Cover Picture



Blending of lube oils is handled by four automatic units at Phillips Oil Co.'s new plant in Kansas City, Kans. Three such units have a capacity of 90 gpm. and a fourth a capacity of 60 gpm. Each unit can handle three separate base stocks and three different additives simultaneously. Various set-ups are arranged by the master manifold using flexible hose, seen at the left

fined to two different levels—one for competitive grade motor oil and a higher level for premium and heavy-duty oils.

The phenol extraction tower, formerly used for butane-splitting, is 95 ft. high in comparison to the 65-ft. height commonly used. This was filled with new internals and consequently there are 24 trays, four more than usual. This has been found a distinct advantage, because the resulting higher extraction efficiency permits the use of a lower phenol-to-oil ratio than customary to get the desired viscosity-index improvement. A marked increase in yields has been noted also, at the expense of more phenol in the system.

Principal innovation in heat economy on the phenol unit is on one of the extract recovery towers. This tower's function is to take a constant boiling mixture of phenol and water overhead, delivering dry phenol-oil solution bottoms to another tower for final recovery. In the conventional design the charge stream is preheated by exchange and enters the tower partially as a vapor. The vapor condenses due to tower temperature at this point, thereby in effect losing some of the effects of preheat.

The Phillips tower preheat train has the usual exchanger sequence, but adds a flash tank between successive banks. Overhead from this flash tank is injected high in the tower, where tray fluid composition is approximately the same. The liquid bottoms then are preheated further before entering the tower at a slightly lower point than usual.

Dewaxing and Finishing

The propane dewaxing unit occupies most of a large two-story building at the east side of the plot, with compressors on the ground floor and three 400 sq ft. continuous rotary filters occupying the second. In most respects the processing is entirely conventional. Its unusual features are the propane recovery system previously described, steam engine-driven propane compressors and use of water-coalescers in the chiller train.

Two 1000-hp. steam-driven, direct-coupled Ingersoll-Rand compressors are used, taking steam at 225 psi. and exhausting at 55 psi. Steam drive was selected largely as a steam-balance proposition for the plant. The nominal 50 psi. exhaust steam is used for stripping operations, for reflux heating coils in the propane fractionation step discussed earlier and for tank farm heating. Less maintenance is anticipated than with engine drives, also.

Filters have standard Oliver internals, recased by Kellogg to withstand higher pressures.

It is planned to add a specific gravity recorder on both the warm and the chilled solution streams; these streams are now controlled as to relative volumes of propane and oil in the mixture and as to temperature. This additional instrument will serve as a check on the accuracy of proportioning the propane to the oil to be dewaxed.

The Phillips plant is said to be the second propane dewaxing plant utilizing water coalescers to minimize freeze-ups. In earlier designs, a battery of heat exchangers was relied upon to remove this water as ice in prechilling the propane. When an exchanger "freezes up," it is taken off-stream to thaw out, cleaned and returned to service.

In the Phillips plant the propane is first cooled to 34° F. by exchange, then run to a vessel called a "pot"—simply a settler—where the water drops out. The remaining water is removed in the chillers, as in other plants, but the quantity is so small that, instead of taking an exchanger out of service every 5 to 6 hours, the usual case, in this plant thawing out is necessary only about every 48 hours.

The clay contacting plant is conventional except for the fact that maximum contact temperature is limited to avoid thermal decomposition, no fired heater is used and the oil is deodorized and dehumidified following contacting. Heat for this "cold contacting" is furnished by 225 psi. plant steam with a maximum

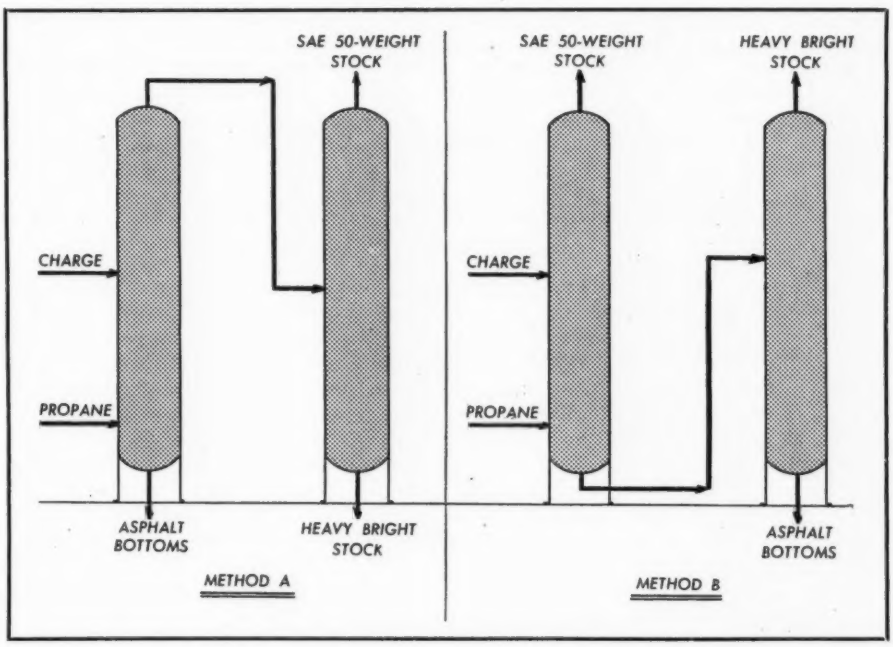


Fig. 1—Two systems of 2-column propane fractionation of heavy lube stocks. Phillips uses Method B, taking lube stocks as overhead product

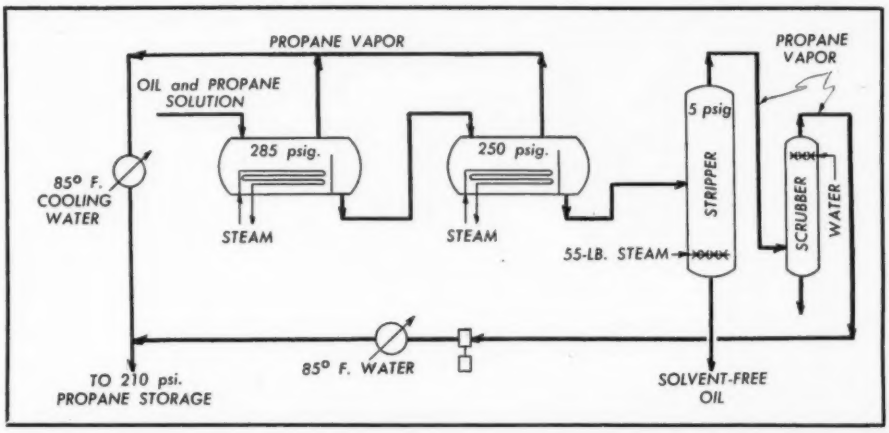


Fig. 2—Diagram of propane recovery system used at propane fractionation and propane dewaxing units. Propane recovery is 95% without use of compressors by stage flashing and cooling with 85° F. water

permissible temperature for the oil set at 360° F. Oliver precoat filters are used to remove the clay.

The deodorizer and dehumidifier is a vessel having for its sole internal an inclined plate with ribbing arranged in the familiar baffle style to spread the oil out into a thin, even film. A pressure of 4 mm. Hg is maintained. By spreading the oil out into a thin sheet, simultaneous removal of odors (from small quantities of volatile matter) and water are achieved.

The final processing step is a clean-up operation to make certain no clay or other solids remain in the oil. The after-filters are Bowsers, consisting of multiple tubes of resin-impregnated cellulose capable of removing solids down to two microns diameter. Careful final examinations are made at this point to assure that stocks meet specifications and no contaminants remain before permitting oil to continue to plant storage.

Plant storage is conventional except that it protects the oil against absorption of moisture due to tank breathing. A closed system is maintained by tieing all vents into a common manifold. Any air which enters must first pass through a bauxite drier. The oil now is ready for blending and packaging.

Blending and Packaging

The canning plant is the "showplace" of the Kansas City refinery. It can handle more than 150,000 gal. of lubricating oil per 8-hour shift and the one-story building has 91,000 ft. of floorspace. Fig. 3 shows the floor plan. The left third of the building is devoted to can and drum storage, and used drum reconditioning. The right third also is storage, for canned and drummed products. The central third is occupied by continuous, automatic blenders, drum and canning machines. Adjoining the building is tankage for base stocks and a large used-drum storage yard.

A basic feature of this plant is that everything has been designed for assembly-line production and no tankage is provided for finished oils. For every stock and additive tank there is a separate line and pump direct to the blending machine, where connections are made with flexible metal hose; thus there is little chance for contamination and poor excuse for a mix-up. The maximum of flexibility is apparent. All pumps are reversible, so that lines can be pumped out to further avoid contamination. Transfer lines from refinery to compounding plant storage are enclosed in a steam-heated trench, and all outside plant lines are steam-traced and insulated.

In the first stage of operation, used drums from the storage yard are inspected for rust or dents and then usable drums are moved by chain conveyor into the building. As they enter, they are spilled head down onto a roller conveyor built over a drainage trench. At the other end they are turned over automatically and carried to the drum cleaning area, where two 6-unit reconditioners wash and dry them inside and out. The drums then are again carefully inspected, and diverted on conveyors either to the paint booth, the repair section, or to junk. From the paint booth the drums pass through an infra-red ray drying tunnel and are allowed to cool. An average rate of over 100 drums per hour can be handled in these preparatory operations.

Reconditioned drums, together with any new ones necessary, are given a final inspection and then pass by conveyor through a tunnel under the working area to the drum filling area.

Blending is performed by four automatic Cornell homogenizing units, three with a capacity of 90 gpm. and one, 60 gpm. Each can handle up to three base oils and three additives simultaneously and, in addition to thoroughly blending the components, they deaerate and dehydrate the blend. A steam heater for the oil is provided ahead of the homogenizer to assure proper temperature, and a water cooler, controlled by refrigeration equipment, reduces the blended oil to proper canning temperature.

Oil leaving the blenders goes directly to drum or canning machines, or to tank cars.

Drums are filled by volumetric temperature-corrected meters on hose-type drum fillers. Two Bowser and two Empire Thermostatic Drum Fillers are used. Drums are stenciled just before filling to identify the product and placed on wooden pallets which are roller conveyed past the fillers. Following closing and sealing, the drums move to the end of the conveyor, to be moved by fork trucks to the north end of the building for shipping. There are three conveyor lines, with two fillers per line.

The canning section has three Continental Can Co. filling machines; with the respective capacities per minute of 250 one-quart cans, 150 one-quart cans and 35 five-quart cans. Each has boxing and sealing equipment and at the end of the conveyor the sealed cases are stacked on pallets for movement by fork trucks.

All packages for a given transport truck order are assembled at one point on the floor before the truck is ordered to pick up the load. Six loading docks are available. Box car orders are loaded direct from the fillers by electric fork trucks. Five box-car loading spots are located inside the building and seven outside. An 8-spot tank car loading and unloading rack is outside the building.

Three small batch blending tanks inside the building provide for blending small quantities of "specialty oils" which cannot be handled economically by the automatic homogenizers. Two are of 324 gal. and the other holds 810 gal. A weight-type drum filler is provided for these tanks. Nearby are ten melt-down tanks for heating and removing from drums the various additives necessary; connections are provided to homogenizers or the small batch blenders.

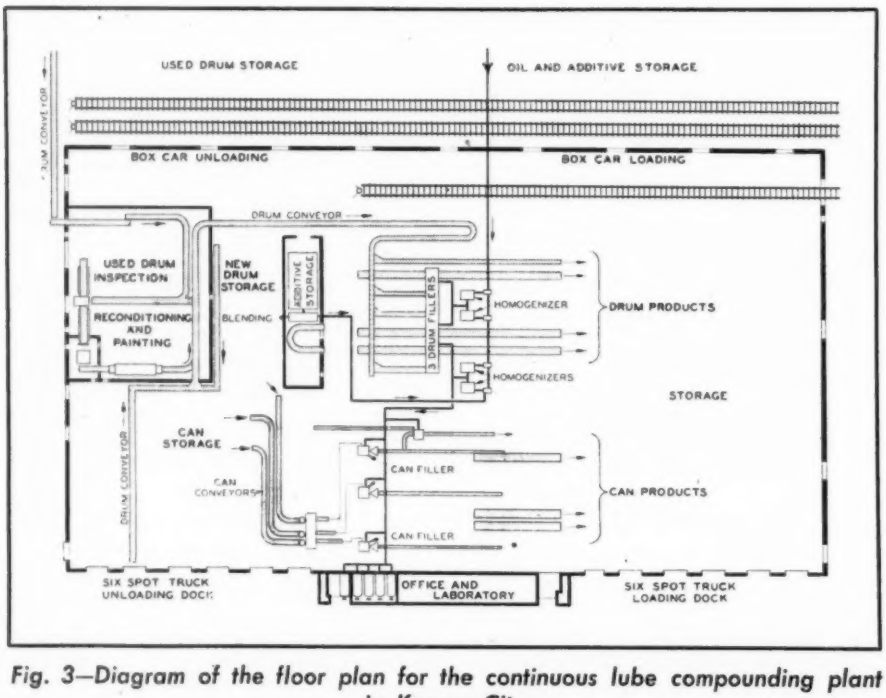


Fig. 3—Diagram of the floor plan for the continuous lube compounding plant in Kansas City

RADIOGRAPHY—
A Refinery Corrosion Inspection Tool

By J. H. STEWART
Industrial Radiography Laboratory, Beaumont, Texas

Radiographic inspection is being used by some Gulf Coast refiners for determining corrosion, wall thickness and other conditions of vessels, piping and so on. Its advantages are that, in many instances, equipment to be studied need not be shut down, and that a source of electric current is not necessary. The technique required is such that in most cases outside service organizations are used. The usual precautions for the storing and use of radium must be followed to protect personnel and avoid "fogging" of film.

RADIUM now is being used in petroleum processing plants as a convenient means to determine metal thickness, the presence of corrosion, and for general inspection, in addition to its more common use for checking welds and examining metals for cracks and slag inclusions. Its particular advantages lie in the fact that:

1. A very small quantity is an exceedingly potent source of radiation (gamma rays).
2. No bulky apparatus is required.
3. The radium container can be inserted in a small or cramped space.
4. A source of electric current is not necessary.
5. Unless in motion, the equipment to be studied often does not have to be shut down. Dismantling usually is unnecessary.

A number of oil companies on the Gulf Coast now are using radiographic inspection for corrosion surveys of refinery vessels, piping, and fittings, well equipment, pipe lines, and the like. Measurements are considered accurate; however, radiographic equipment does have the same disadvantage as X-ray inspection means—it does not provide an immediate answer, as do such devices as the Penetron (also using a form of radium) or other instruments using sound waves or magnetism. A photographic negative is required, and especially trained personnel must interpret the results. Consequently, most companies find it convenient to employ "outside" service organizations as an adjunct to their inspection departments.

Theoretically, a radiographic inspection is no more complicated than the better known X-ray examination. The method consists essentially in placing a radium container at a suitable distance on one side of the

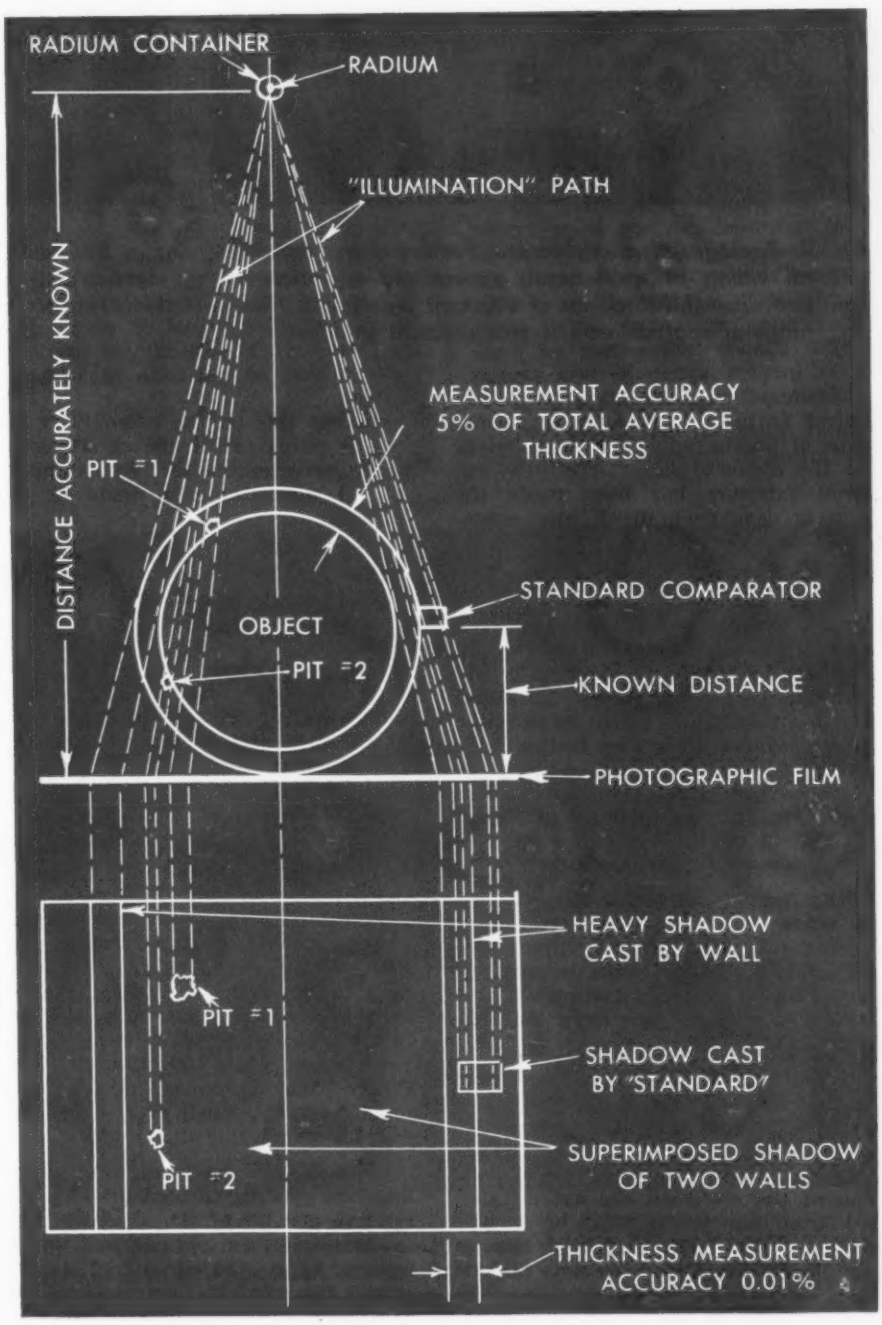


Fig. 1—Schematic diagram of how radiographic inspections are made with notes on interpretations

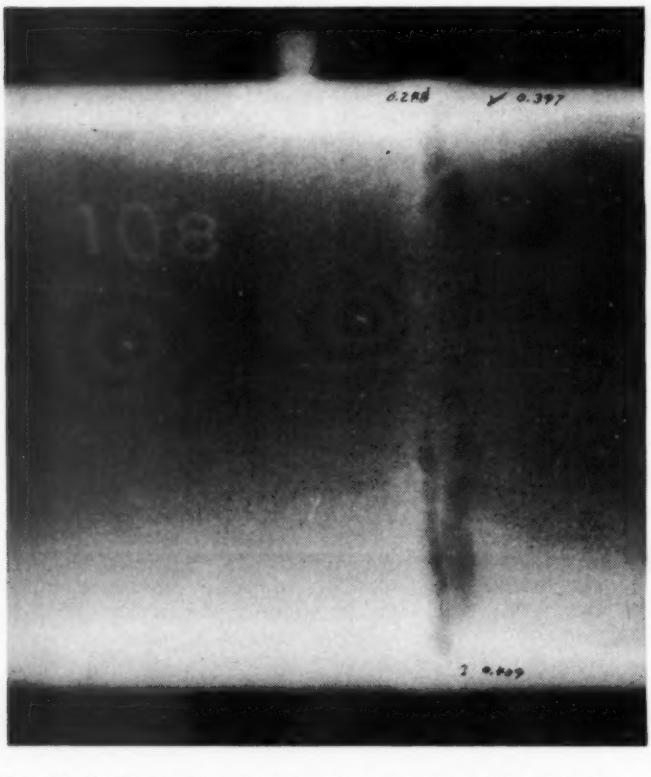


Fig. 2—Radiograph of visbreaker furnace tube showing internal pitting at weld bead, generalized corrosion of wall and dissimilar thickness of adjacent pipe joints. Rectangular spot on wall is measurement standard

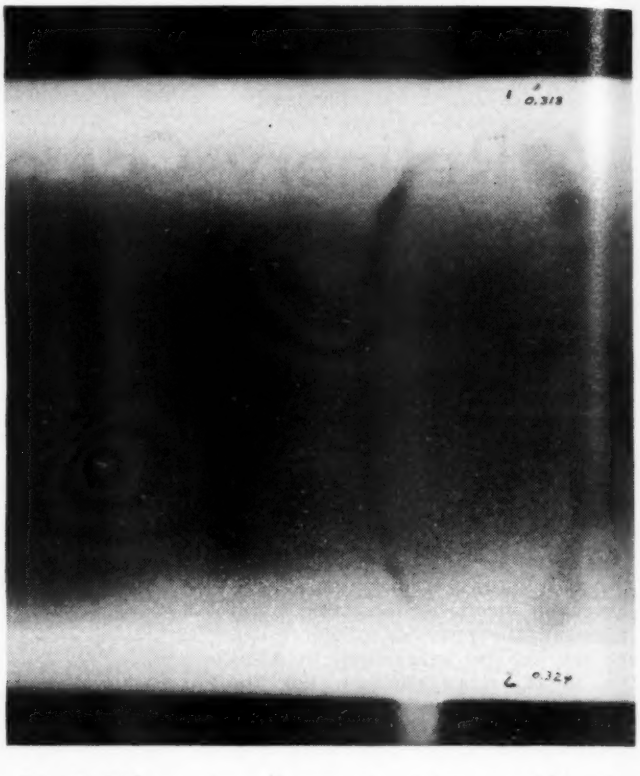


Fig. 3—Oblique view of same pipe joint at weld. Pits at right are distorted, being on far side of pipe from film. Note effects of wear from turbining as consequence of different pipe inside diameters

object to be inspected and a special type of photographic film in a holder on the opposite side. After the desired exposure has been made the film is developed, dried, and examined.

Examination of the "photograph" may be visual, by densitometer, or both. Cracks and other discontinuities, including welds, show up as shadows of varying density as in the familiar X-ray negative. Localized corrosion—pitting—often is similar in appearance to a slag inclusion or cavity, while areas of generalized corrosion are lighter in appearance (less dense) than unattacked areas.

Interpreting the Radiograph

The radium source for all practical purposes may be considered as a theoretical point source "illuminating" the specimen. This is particularly important in interpreting the result, as may be seen from the diagram of Fig. 1.

The "standard" gage, shown mounted on the side of the pipe used for illustration, is the reference to which all measurements are made. The actual dimensions and composition of the standard are not critical but true dimensions must be accurately known. The standard should be placed tangential to the object and approximately at right angles to the radiation path. Calipering its apparent size on the radiograph and relating this to its known size gives the "correction factor" to be applied to all measurements made on the radiograph.

Thickness determinations, as corrected, range in accuracy from 0.01 in. for the heavy wall shadows to approximately 5% of the thickness involved for the superimposed area of the double thickness of pipe in the center of the radiation path. Thus, while wall thickness measurements of the pipe at its edge are quite accurate, that of the two superimposed areas amounts to an average thickness.

By their shadows, irregularities can be accurately located on the object inspected, even though the shadows may be superimposed on others. Shadowy areas of sharp, definite outline are on the side of the object next to the film. They are so close, in other words, that they are not much distorted by divergence of rays from the point of "illumination." Fuzzy, shadowy areas, on the other hand, are at a much greater relative distance from the film.

Generalized corrosion, as well as localized pitting, is measured by the relative density of the shadows cast. In this case an optical instrument known as a "densitometer" is required for accurate comparisons. In any case, the measurement is relative, but it may be tied to a known thickness of metal by radiographing the standard under the same conditions (preferably on the same film) used for the object. Ordinarily, sufficient accuracy is obtained by setting the densitometer at zero on the lightest shadow visible and then comparing this with other parts of the radiograph.

By a knowledge of the distances between radium and object, as well as between object and the standard comparator, location and depth or size of pits, cracks, and foreign materials can be estimated by calipering and applying the distortion correction. The thickness of remaining metal is indicated by relative density of the shadow.

So-called "penetrameters" are used frequently to measure the "radiographic sensitivity" of the exposure. They serve as assurance to the radiologist that a satisfactory exposure was made. "Penetrameters" are specimens of the same metal as the object being examined. Their thickness is accurately known and sets should be available ranging from 2, 4 and 8% of the thickness of the metal under investigation. They are taped to the specimen itself, if possible on the side away from the film. Their shadows are particularly valuable in estimating thicknesses by densitometer measurements.

The photographs of Figs. 2 and

TABLE 1—Sample of Data from Radiographic Survey of Vis-breaker Furnace Tubes

Position Tube No.	Factor	1	2	3	4	Densitometer 1
99	0.638	0.384	0.405	0.287	0.298	0.342
104	0.698	0.476	0.524	0.547	0.468	0.478
150	0.683	0.570	0.546			
115	0.698	0.605	0.589			
85	0.654	0.589	0.589			
186	0.682	0.455	0.420	0.601		

3 were made of a visbreaker coil in the furnace of a large Gulf Coast refinery in the course of a radiographic inspection for corrosion. The results are of considerable interest for, as often happens, they revealed the presence of the unexpected.

Fig. 2 shows a section of a visbreaker furnace coil in the area of a weld with thickness determinations of critical areas marked. The pitting-type corrosion attack in the weld bead is very evident. In the original negative it is not difficult to distinguish between fuzzy-appearing pits and sharply-defined ones, denoting areas on the far and near sides of the pipe, respectively. The numerals denote thickness of metal remaining. Table 1 shows some of the data from this survey.

This and other photographs of similar areas also indicated why the refinery maintenance department was reporting unexplained trouble. Inspection of the dense wall shadows clearly reveals that the two pipes joined at the weld do not have the same wall-thickness. Thus, when the coils were turbined the cutter blades actually wore away part of the pipe wall where two different wall-thicknesses were involved.

Fig. 3 is a similar view, with the radium at an acute angle to the major axis of the pipe. This shows the weld area as an ellipse, shadow superpositioning of weld-bead pitting is eliminated, and permits more accurate measurement of pit depth.

Fig. 4 shows the application of radiographic inspection to distillate well corrosion and illustrates the dual advantages of the method because of its ready portability and independence of electric power circuits. The ell on this gathering line, to the side of a Christmas Tree, was suspected of damage. The effect of a combination of erosion and corrosion in the curve of the ell is evident from the marked thinning of the wall which can be noticed at that point. Other portions of the ell and adjacent pipe do not seem to have been materially damaged. It was not necessary to disturb well operation for this inspection.

Fig. 5 represents a small centrifugal pump. The internal arrangement of parts is quite clear and, on the original, some of the individual balls in the shaft bearing may be distinguished. As reproduced for publication, the shaft bearing is visible as concentric with the fluid inlet flange, both circumscribing the dense spot representing the impeller shaft. It can be noted also that some of the casing nuts had been removed before the radiograph was made.

Making the Radiograph

The decision of where to make the inspection has no specific rules. Usually points are selected as the plant inspection department designates and generally the same criteria govern as in selecting areas where drilling for direct measurement is practiced. In "new" cases where there is no backlog of experience, it may be necessary to make "exploratory" shots until something of significance is found. Under such circumstances, prime suspects usually are the areas of, and adjacent to, welds and swages, or where leaks have been observed, followed in importance by areas containing elbows or sharp turns. Unless the subject is a furnace tube or large vessel, where access to the interior is necessary, the equipment need not be shut down.

Generally it is desirable to remove the insulation from lines because the nearer the film is to the surface of the pipe the clearer will be the shadow picture. Where the line is extremely hot this cannot be done, as great heat will damage the films. In some "hot jobs" it is necessary to use additional insulation and provide for cooling air circulation between film holder and pipe. Temperatures in excess of 150-160° F. will damage radiographic film.

Suggested practice calls for stenciling lines and areas, and filling in the depression with metallic lead. This positively identifies the area radiographed and at the same time facilitates positive relocation of the area for future reference.

Exposure times vary with the distance of radium to film, the quantity of radium, the filters used, and also the thickness and kind of metal under examination.

A given capsule contains a specified amount of radium, hermetically sealed in a silver "bullet." This is placed within a duraluminum container for use. Rings at strategic locations on the container permit attachment of string to support the container in place and for handling during placement. Radiation intensity from a specific container is accurately known and drops less than 3% per century, as long as the "bullet" is not ruptured. Radium, or some other source of gamma rays such as radioactive cobalt, may be leased and is under control of the U. S. Atomic Energy Commission.

Since radiation intensity remains constant, a knowledge of metal com-

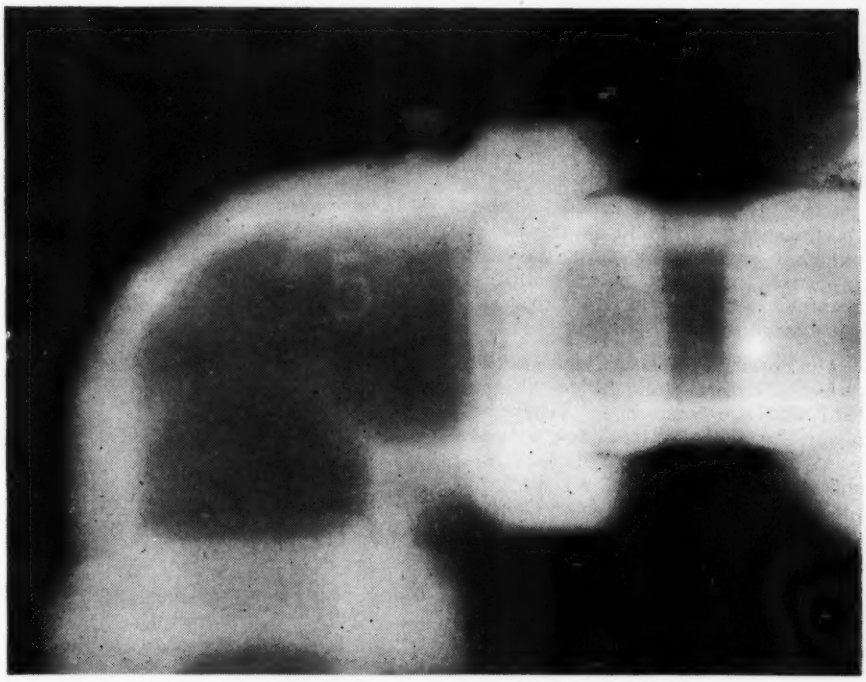


Fig. 4—Effect of corrosion in distillate wells is shown in this radiograph of piping. Note erosion and corrosion has dangerously thinned area of the bend in the ell; adjacent fittings are unattacked

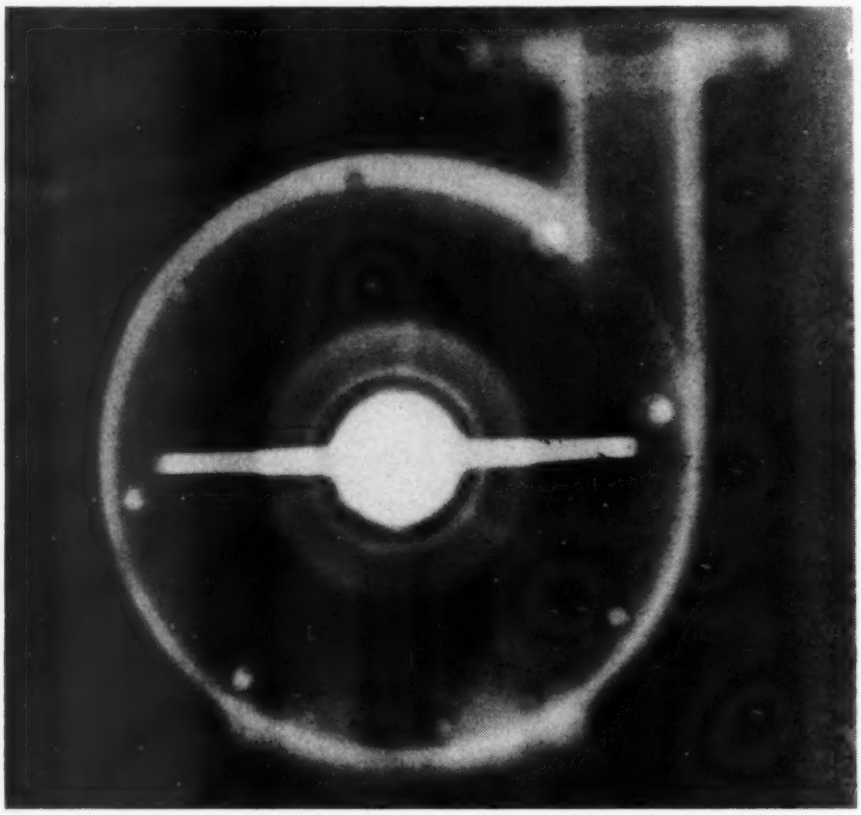


Fig. 5—Radiograph of small centrifugal pump, showing impeller, bearing ring and inlet flange. Impeller shaft can be distinguished clearly on original negative, and some of the balls in the bearing

position and thickness, "film factor," and distance of radium to film permits accurate estimation of required exposure time. Sometimes exposures range up to one hour; ordinarily 15 to 30 minutes is sufficient. Quite frequently inspections of several areas are made simultaneously, using the same radium source. Where vessels or pipes exceed 36 in. in diameter, best results will be secured by placing the radium inside. Metal thicknesses of up to 10 in. of steel can be radiographed without excessive exposure times but best results are obtained where total thickness does not exceed 6 in.

The relative positions of radium, object of interest and film are important and are learned by experience: often these are critical for satisfactory interpretation. Not only may the distortion of shadows and geometrical appearance be radically altered by different positions, but good "visibility" and exposure times are affected as well.

Various mechanical expedients may be necessary to orient film, object and radium properly. This is especially true in restricted working spaces. "Filters" such as aluminum, cadmium, lead and other metals may be used to screen out various unwanted radiation wavelengths to permit outlining special objects; "intensifiers" are used similarly to bring up contrasts. Composition of these radiographic aids and their placement on film or object are commonly considered "tricks of the trade."

Safety Practices

Last, but not least, proper precautions must be taken at all times in the presence of radium, whether it is stored or in use, to protect personnel and avoid "fogging" of film. The reputation of radium as a deadly material is undeservedly bad and results largely from ignorance and carelessness. Radium is no more dangerous to use than an X-ray machine and will not induce secondary radioactivity in materials with which it comes in contact. It is not an atom bomb but, like sulfuric acid or strong caustic, it can cause death if mishandled.

A radium "burn" is like an X ray "burn" in that it is insidious, gives no warning for hours up to days. Exposure effects are cumulative over short periods. The presence of radiation may be detected by blackening of photographic film, fluorescence of some compounds of barium, platinum or zinc, the Geiger counter and the electroscope. Geiger counters and occasionally electroscopes are used to survey radiographic setups for harmful radiation.

The obvious safe practice is to keep radium shielded behind lead at all times when not in use by trained personnel. The table of safe working distances determined by the U.S. Bureau of Standards and reproduced in Table 2 should be used as a guide. Metal such as lead is an excellent shield, and thick brick or concrete walls offer considerable protection. The maximum safe human dose is considered as 100 milliRoentgens in eight hours or the radiation from 100 mg. of radium 3 ft. away for eight hours.

Unshielded radium should never be left unguarded, carried in the hand or pocket under *any* circumstances. Film should be positioned and everything made ready before the radium is brought from its lead box to make the radiograph. A "dummy" container should be used in arranging positioning, supports, etc.

Workers should wear light-tight film badges containing radiographic film covered by lead, aluminum and cadmium screens of varying thicknesses; these permit measurement of amount and kind of any radiation to which the wearer has been subjected. Developed daily as a routine safety assurance, they can be developed immediately in the event the wearer believes he has had a "dose."

A blood count after a few hours will confirm a positive badge warning. Should the count be less than 5000 white cells, another count should be made seven days later to observe progress. Meanwhile the worker should be relieved of radium-handling duty. If the count still is low, the worker should not again be exposed to possible further radiation until the minimum white count level is restored. All personnel should have blood counts made every three weeks as a routine precaution against accumulative exposures.

It is advisable to erect barriers carrying signs warning passers-by of possible danger during radiographing. Care should be taken not to accidentally expose other personnel working in the vicinity and, if necessary, move them to a safe distance. Presence of idle on-lookers should be firmly discouraged. The radium storehouse should be kept locked to discourage the curious.

TABLE 2—Safe Working Distances for Radium, Daily Exposures*

Milligram-hours	Safe Distance feet**
100	3
200	4
400	6
800	8
1600	11
3200	15

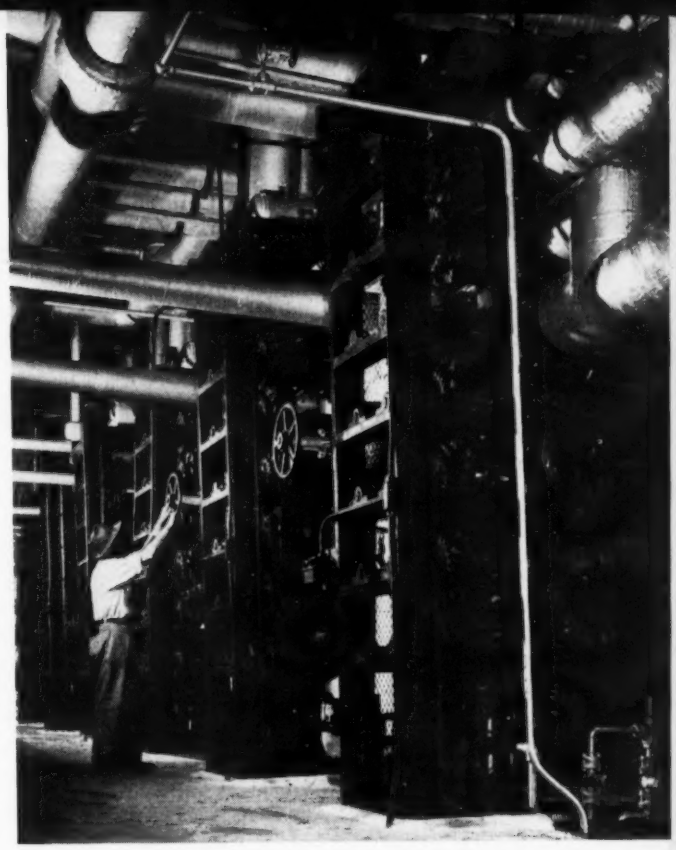
* U. S. Bureau of Standards.
** With air as an insulator.

UBE OIL PLANT

The Pennzoil solvent (ketone-benzol) dewaxing plant at Oil City, Penna., is the first installed to operate in "reverse sequence", producing finished grade of wax at an intermediate temperature in a primary operation, followed by production of low pour point oil in the finel operation. Changes in the primary distillation equipment at the refinery eliminated the slop wax distillate fraction.

The six rotary drum vacuum filters of the dewaxing unit are arranged so four can be used either for the primary or dewaxing operation. A design innovation is the use of individual rotary pumps for removing the wax mix directly from the filters. The processing of cylinder stock is substantially the same as for neutral wax distillate. A repulp cycle was added and successfully achieved higher yields of both wax and neutral.

This paper was presented at the 47th Annual Meeting of the National Petroleum Assn. in Atlantic City, Sept. 15, under the title "Solvent Dewaxing and Wax Manufacturing from Pennsylvania Grade Crude Oil." It is published here in essentially its complete form.



Chillers for chilling oil-wax and solvent mixtures

'Reverse Sequence' Dewaxing Cuts Solvent, Refrigeration Needs

By J. M. HINMAN, General Superintendent, Pennzoil Co., and R. R. MADDOCKS, Process Engineer, Arthur G. McKee & Co.

THE solvent (ketone-benzol) dewaxing plant of the Pennzoil Co., Oil City, Pa., is the first to be designed on the so-called "Reverse Sequence" basis.

The normal sequence of practice in the past has been to dewax the oil first and reprocess the wax as a second step. Many such installations consisted of a separate unit for the two operations, which could be practiced in series or parallel flow.

The advantage of the "Reverse Sequence" operation over the "Normal Sequence" operation is the production of a finished grade of wax at an intermediate temperature in a primary operation, followed by the production of low pour oil in the final low temperature operation, thereby reducing the requirements of both refrigeration and dilution solvent. The intermediate dewaxing temperature required for wax production is determined by the melting point of the wax desired.

The Texaco Development Corp. is the licensor of the process. The unit itself was designed and constructed by Arthur G. McKee & Co.

In addition to the base contract for the design and construction of the Solvent Dewaxing Plant, the McKee company studied the performance of the existing primary distillation equipment. As a result, certain changes were made to eliminate the usual "slop wax distillate" fraction. These changes provide a means of continuously refractionating a heavy wax bearing distillate resulting from the manufacture of high flash cylinder stock. This refractionation yields a wax distillate overhead, which contains a crystalline type wax. The resulting bottoms are returned to the main fractionating tower and introduced directly above the bottom stripping section.

The solvent dewaxing plant at Oil City was designed to remove 260 BPOD of product wax (130-133° F. melting point) and 130 BPOD of slop wax when dewaxing 2500 BPOD of neutral oil to 0° F. pour point, or remove 80 to 85 BPOD of microcrystalline wax (140-145° F. melting point) and 128 BPOD of slop wax when dewaxing 1600 BPOD of residual cylinder stock to +5 to 0° F. pour point. (The aforementioned numerical values are given for exemplification and are not necessarily the exact process design or operating quantities, but are reasonable approximations.) Although these design data represent the primary design basis, one must realize that the demands for various waxes continually change. Therefore, a plant of this type must be capable of handling a wide range of waxes in distillates and produce the most favorable product by the best practical means. In order to provide this flexibility, consideration was given to the possibility of performing three general types of operation, namely, (1) producing wax and dewaxing oil by reverse sequence, (2) dewaxing oil and repulping the waxes by normal sequence and (3) conventional solvent dewaxing only. Referring to the accompanying simplified flow diagram, Fig. 1, the flow through the unit is as follows:

Reverse Sequence

Neutral Operation

In charging neutral stock, the stock is chilled to the desired primary filtering temperature by means of a water cooler, exchange with cold dewaxing filtrate and final chilling by direct expansion of ammonia. The primary filter temperature is deter-

"Reverse Sequence" Dewaxing

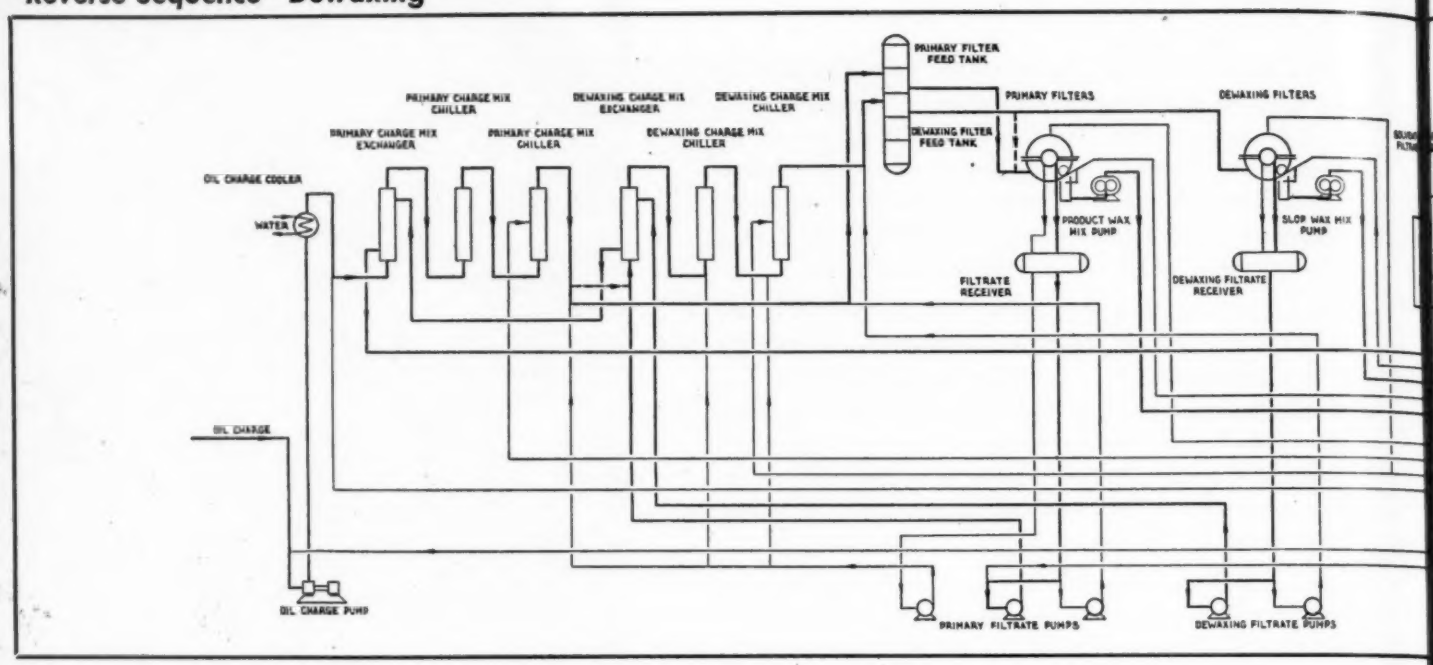


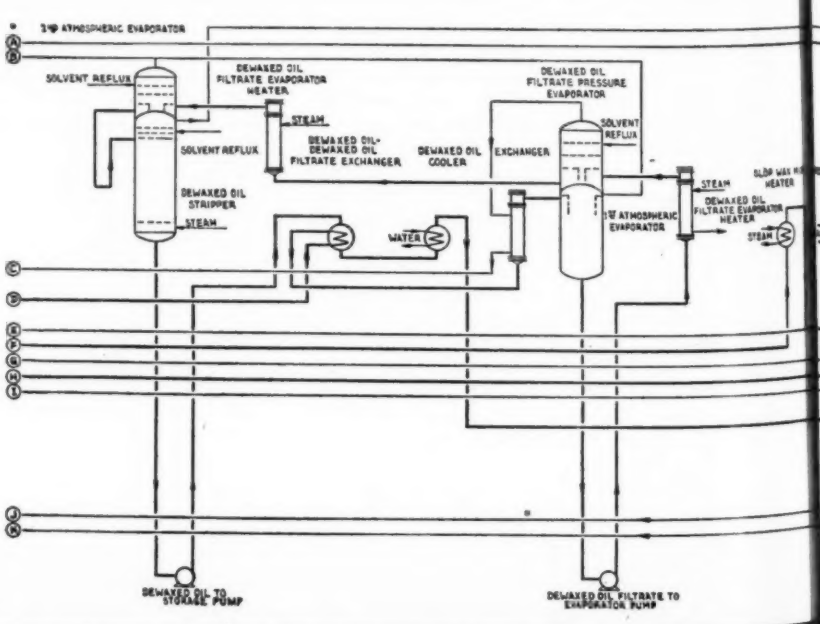
Fig. 1—Above and at bottom of page: flow chart of Pennzoil's dewaxing plant

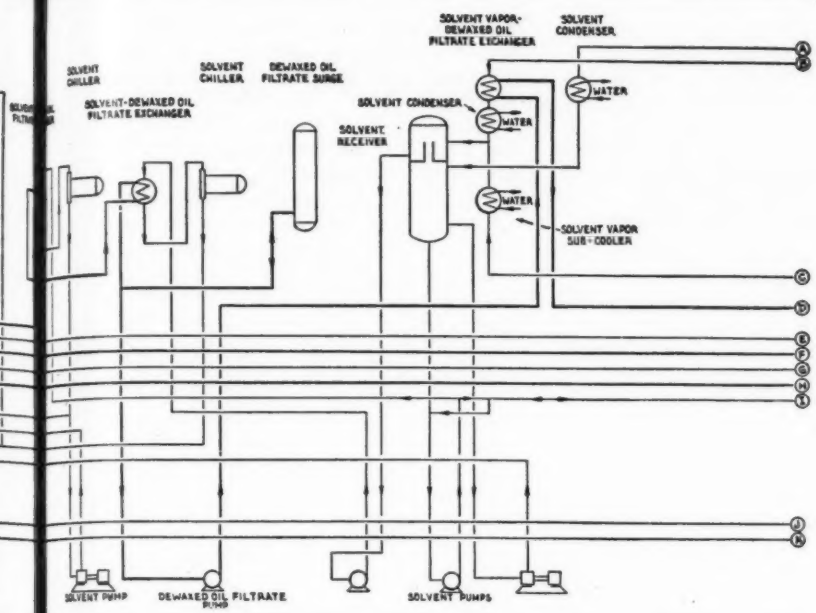
mined by the desired melting point of the product wax. In this particular case, the primary filters are operated at 30° F. and the product wax has a melting point of 130° F. Chilling of the charge oil is started in the absence of solvent and during chilling solvent is added in increments at one or more points. Such addition of solvent tends to promote crystal growth without the customary occlusion of oil. The small dense crystals formed under such conditions can be easily washed. This condition of the wax crystal contributes much to the low oil content of the final wax product.

The cold filtrate exchangers and the ammonia chillers are of the double pipe, scraped surface type. The cooling medium flows through the annular space between the two pipes of which the outer pipe is 8 in. in diameter and the inner 6 in. The inner pipe contains a rotary scraper, which aids in chilling by preventing accumulation of wax due to settling or to its adhering to the pipe wall. The cold filtrate exchangers and ammonia chillers are built up so that each group contains 12 or 14 sections, 45 ft. long, arranged in two stacks, each containing 6 or 7 tubes respectively.

The primary filter feed tank provides gravity flow to three rotary drum vacuum filters. The filter hood contains flue gas (CO_2 and nitrogen) under a slight pressure, and a vacuum is maintained in the filtrate receiver by means of a vacuum pump. This vacuum pump circulates flue gas which facilitates cake drying and cake discharge. The speed of the drum rotation is 3 to 4 minutes per revolution. However, this can be and is varied. The rotating element is made up of a number of shallow compartments over which is placed screen and cloth. These compartments are connected by separate pipe systems to ports in the trunnion. Only ½ of the drum is submerged in the material to be filtered. When the submerged compartments are subjected to a vacuum, the filtrate is drawn through the hollow trunnion and wax is deposited on the drum. When a compartment emerges from the liquid, the ports draining that compartment enter a compartment of the valve in which a vacuum is maintained which is independent of the vacuum during the cake forming portion of the cycle. Chilled solvent for reducing the oil content of the wax cake by a "piston displacement" type of wash is sprayed upon the surface of the deposited wax.

After a section of the filter has passed through the cake forming and cake washing portions of the filtration cycle, it enters a cake drying zone. A third degree of vacuum, independent of that in the cake forming and cake washing zones, is maintained during cake drying. When the cake is reasonably dry, a back blowing set of ports is reached and bond between the cake and the filter cloth is broken so the cake slides freely over a deflector plate into a trough, where rotating scrolls remove





it into a wax mix receiver. For the first time individual rotary pumps were successfully installed for the removal of wax mix direct from the filters. Previously, reciprocating pumps were used with a fair degree of satisfaction to pump the wax from a tank into which the scrolls discharged the wax. A three-lobe rotating positive displacement pump is very satisfactory if operated at a suitable speed. The wax mix comprising about 60% solvent as removed from the primary filters is transferred through a steam heater to a product wax mix surge tank prior to wax recovery.

In the dewaxing step, oil-rich primary filtrate (55% solvent) is pumped through a double pipe, scraped surface, cold oil exchanger and then chilled to the desired dewaxing temperature in double pipe, scraped surface, direct expansion ammonia chillers. The final temperature is determined by the desired pour point of the dewaxed oil. Solvent is added incrementally during chilling as in the previous step.

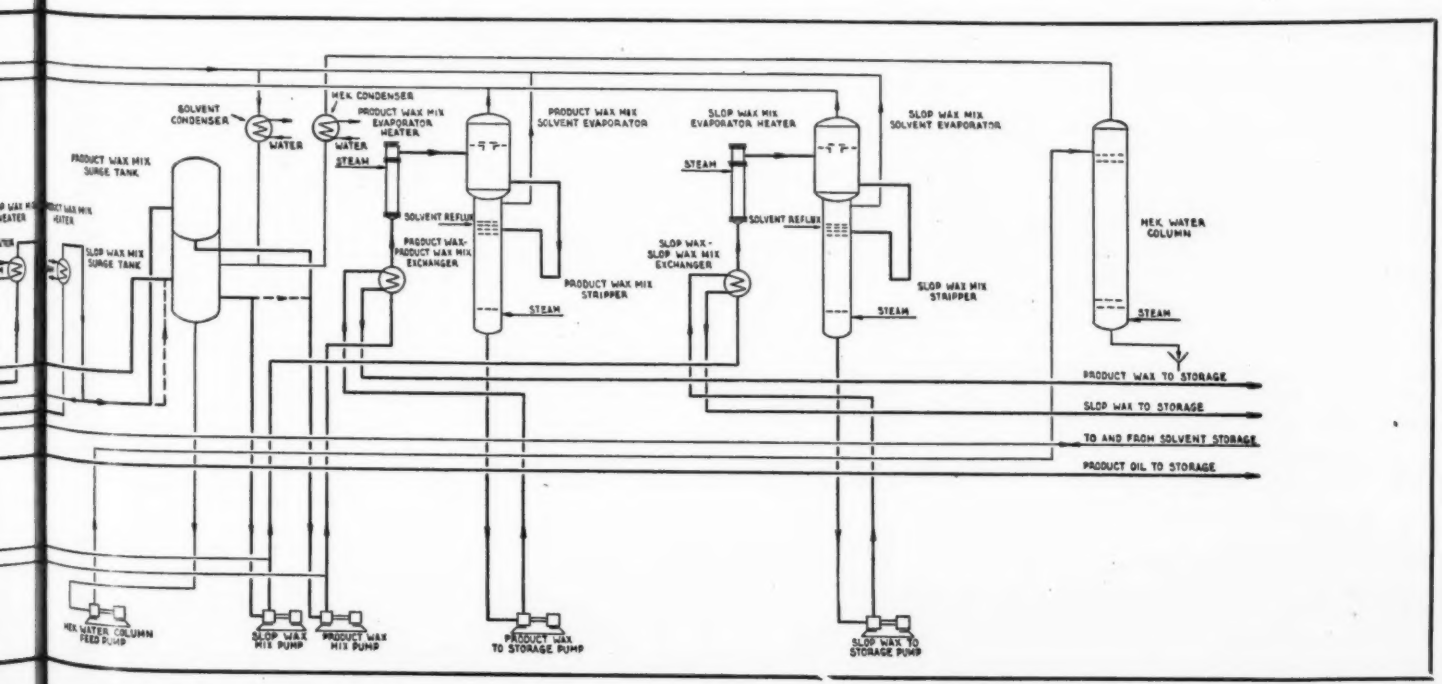
The chilled oil-solvent mixture flows by gravity from the feed tank to the three dewaxing filters, where it undergoes a similar process as indicated for the primary filters. In this operation the wash filtrate is not segregated from the dewaxed oil filtrate. The total filtrate (typically 25% oil, 75% solvent, total) is pumped back through the aforementioned cold oil exchangers, through two solvent coolers and thence to the recovery section. The slop wax mix is transferred from the filter through a steam heater to the slop wax mix surge tank prior to recovery. This soft low melting point wax removed during the second filtration has a rather limited market compared to the demand for the harder type.

For flexibility, the six operating filters are arranged so that four filters can be used for either the primary or dewaxing operation. Each filter contains 500 sq. ft. of surface.

All heat in the solvent recovery section is supplied by 135 psig. steam. The steam requirement is kept to a minimum by multiple effect evaporation.

The dewaxed oil filtrate entering the recovery section is preheated by dry solvent vapors (vapors from first and second atmospheric evaporators), stripped oil, and overhead vapors from the pressure evaporator. The solvent is flashed off in three stages and the product oil is finally steam stripped to remove any remaining traces of solvent before transferring to storage. Of the total solvent contained in the dewaxed oil filtrate, the volume flashed off in the respective stages is as follows: 47% in the first atmospheric evaporator, 47% in the pressure evaporator, 5% in the second atmospheric, and finally 1% is removed in the product oil stripper. Steam evaporator heaters vaporize the solvent removed in the pressure and second atmospheric evaporators.

The product wax and slop wax recovery systems are identical and each is designed to recover 260 BPOD of wax. Although 60% solvent was anticipated in the wax mix streams to



the recovery section during normal operation the recovery equipment was designed to remove a higher percentage of solvent. Solvent-wax solution from the wax mix surge tank is pumped through the wax stripper bottoms exchanger and the evaporator heater to the atmospheric evaporator, where all except 4% of the solvent is removed.

Solvent removed from both the product wax and slop wax evaporators flows to the moist solvent receiver. As previously mentioned, the dry solvent is recovered from the three evaporators in the oil recovery system. The solvent storage drum is designed so that excess dry solvent continuously flows into the moist solvent receiver. The two recovered solvent streams are segregated for convenient re-use. The condensed overhead vapors from all strippers pass into the slop wax mix surge tank, where water separates. Due to the solubility of MEK in water, the water layer in the surge tank is charged to an MEK stripper from which the water flows to the general water recycle system. It will be noted that all water leaving the unit, whether it be derived from the oil charge or from steam used for stripping, must pass through this MEK stripper. The total solvent loss, due to spills, leaks, etc., amounts to less than 0.03% of the solvent circulated to the recovery units.

Cylinder Stock Operation

It is possible to terminate a run on one stock, wash the system with solvent, and be on stream, dewaxing a dissimilar stock within five hours. The processing of cylinder stock is substantially the same as described for neutral wax distillate with few exceptions. Incremental dilution is not used. All solvent is added to the oil initially, before chilling. The primary filters are operated at 30° F., which is suitable for the removal of high melting point micro-crystalline wax.

Design calculations indicate the refrigeration requirements for the two operations described to be practically the same. This results from higher solvent dilution required to dewax cylinder stock. The two-stage system installed provides 350 tons of refrigeration by direct expansion of ammonia. The refrigeration load is divided between three two-stage ammonia compressors. Table 1 gives operating results for the wax distillate primary dewaxing operation.

Repulp Cycle

Neutral Operation

The repulp cycle was not added until sufficient data could be collected from actual plant operation to determine its flexibility, when operating on more than one type of reduced wax distillate. After completing the runs and producing a fairly wide range of melting point waxes, the changes necessary to add the repulp cycle were studied in detail. At this point, it may be well to note that all materials required for the changes were fabricated and on hand, and only 16 off-stream hours were lost in converting to this operation.

The wax produced in the repulp cycle comprises all of the wax fractions removed from the charge oil when producing dewaxed oil of 0° F. pour point. These waxes as charged to the repulp cycle have an average melting point of 116° F. and contain not more than a total of 6% of oil and soft waxes. The wax mix which is comprised of 20% of waxes and 80% of solvent diluent is further diluted in the filter scroll to produce the final desired dilution and temperature for repulp filtration. Once the conditions of solvent wax mix and temperature are established, no further heating or cooling is required. The wax-bearing solution is pumped directly from the filter scroll to the filter feed tank. The final wax bearing solution feed to the repulp filters contains 6% of total waxes and oil and 94% of solvent.

The rate of filtration under these conditions is constant. The filter cake is washed with cool solvent, the temperature of the wash solvent being varied to effect an increase in the melting point in the final wax. Care must be exercised in this operation to prevent an excessive rise in the cloud point of the finished neutral. The amount of low melting point wax removed from the total wax by increasing the temperature of the repulp filter wash is practically a quantitative amount. The filtrate from the repulp cycle containing approximately 4% of oil and soft wax is recirculated.

The added repulp cycle has an advantage in the overall operation in that higher yields of both wax and neutral are obtained. The product classed as slop in the primary operation is included in the finished products from the dewaxing and repulp operations. Because of the increase in product wax yield (approximately 50%) both wax recovery sections of the unit are used for its recovery.

The dewaxed neutral oils from the dewaxing cycle have a minimum cloud point of 6° F. while maintaining a pour test of 0° F. The final wax product is finished to a minimum A.M.P. of 124° F. and contains not more than 1.0% of oil. Table 2 gives results from the wax distillate repulp dewaxing operation.

TABLE 1—Wax Distillate Primary Operation

Wax Distillate Gravity, °API	32.0
Product Wax Gravity, °API	42.3
Product Wax Melting Point E.M.P., ° F.	132.6
ASTM Oil Content, % Oil	1.1
Slop Wax Gravity, ° API	40.2
Slop Wax Melting Point ° F.	99
ASTM Oil Content, % Oil	9.9
Neutral Cloud, ° F.	10
Neutral Pour, ° F.	0
Charge, Bbl./Day	2574
Neutral, Bbl./Day	2131
Neutral %	82.8
Product Wax, Bbl./Day	260
Product Wax %	10.1
Slop Wax, Bbl./Day	183
Slop Wax %	7.1

TABLE 2—Wax Distillate Repulp Operation

Wax Distillate Gravity, ° API	32.0
Wax Gravity, ° API	42.0
Wax Melting Point, E.M.P. ° F.	122
ASTM Oil Content, % Oil	1.0
Neutral Cloud, ° F.	6
Neutral Pour, ° F.	0
Charge, Bbl./Day	2578
Neutral, Bbl./Day	2165
Neutral %	84.0
Wax, Bbl./Day	413
Wax %	16.0

TABLE 3—Cylinder Stock Straight Dewaxing Operation

"D" Stock Gravity, ° API	26.7
"D" Stock P.M. Flash, ° F.	535
"D" Stock Vis. at 210, SSU	138
"D" Stock Pour, ° F.	85
Bright Stock Gravity, ° API	25.9
Bright Stock P.M. Flash, ° F.	530
Bright Stock Vis. at 210, SSU	147
Bright Stock Pour, ° F.	10
Wax Gravity, ° API	32.2
Wax P.M. Flash, ° F.	525
Wax Viscosity at 210, SSU	103
Wax Melting Point, ° F.	125
Wax, ASTM Oil Content, % Oil	6.8
Charge, Bbl/Day	1742
Bright Stock, Bbl./Day	1464
Bright Stock %	84.0
Wax, Bbl/Day	278
Wax %	16.0

Straight Dewaxing

Cylinder Stock Operation

The "straight dewaxing" operation is simple compared to the preceding methods. The function of the major items of equipment is substantially the same, but with some changes in flow. The oil is chilled directly to the final dewaxing temperature which again is determined by the desired pour point of the finished oil. All dilution solvent required is added initially. The wax cake removed by filtration is pumped to the recovery section, where it is processed as finished petrolatum. No slop wax is produced. Table 3 gives results of the cylinder stock straight dewaxing operation.

The solvent dewaxing unit was first put on stream in August, 1946, and met acceptance tests shortly thereafter. Since that time, the unit has continually dewaxed cylinder stock or neutral distillate successfully.

The flow sheet used in connection with this article was supplied by D. W. Wilson, Arthur G. McKee & Co., Cleveland. W. P. Gee, Texaco Development Corp., New York, assisted in reviewing the paper.

Low-Velocity Water Fog Effective For Refinery Acid Sludge Fires

THE effectiveness of a low-velocity water fog for extinguishing fires in acid refinery sludge, or in mixtures of light ends with a considerable volume of sulfuric acid, was determined as a result of the recent experience of a unit of the U. S. Navy Fire Fighters School, Philadelphia, in controlling a fire in a refinery there, Navy authorities have reported.

Navy personnel helped Gulf Oil Corp. workers fight a fire in a tank at first believed to contain gasoline and light lubricating oil ends. The crew, part of a unit of the U. S. Naval Damage Control Training Center at the Philadelphia Navy base, under command of Capt. C. E. Harrison, U. S. N., brought with them a portable high-capacity fog-foam unit. This was originally constructed to train aircraft carrier personnel in the operation of similar stationary systems aboard ship.

The equipment was placed about 30 feet from the tank and approximately 3300 gpm. were applied in anticipation of rapid coverage and smothering. The fire decreased in the area of application but increased at other points. It then was determined that sulfuric acid was present and subsequently that the mixture consisted of 85% acid and 15% light ends.

Naval personnel then suggested the proper extinguishing agent would be low velocity fog in volume. However, facilities for low-velocity fog application were not available and the fire eventually was extinguished with foam after draining off and diluting the acid. Cooling lines also were applied to the external shell of the burning tank and to others nearby, successfully preventing further spread of the fire.

Variance of opinion as to the most effective means for extinguishing a refinery fire of this nature led to a series of test fires arranged by the Navy Fire Fighters School, the oil company, the Philadelphia fire department, and other interested parties. These were held on the school grounds at the Philadelphia Naval Base.

The conditions under which these tests were made, the equipment employed and results obtained are as follows as reported by the Navy Public Information Office:

Test Equipment and Conditions

1. Five-ft. round tank with 1-ft. freeboard.
2. Seven to one (H_2SO_4 to Light Ends) proportion was maintained to simulate conditions of actual refinery fire.
3. Each fire test primed with 1 pint of gasoline.
4. Three minute preburn all fires.
5. Weather overcast, moderate breeze held during all tests.
6. Quantity of extinguishing agent limited to simulate in proportion, practical amount that could be applied on actual refinery fire.

Test Fires

1. One 15-lb. cylinder of CO_2 was not sufficient; a second 15-lb. cylinder applied in conjunction. Fire extinguished. This result was as expected, the efficiency of CO_2 being

Group of Navy fire fighters assist company employees in battling an acid sludge fire in a 15,000 gal. tank at Gulf Oil Corp.'s Philadelphia plant. (U. S. Navy Photo)

seriously limited by wind dispersal. One reflash during extinguishment. Approximately 25-lbs. CO_2 used.

2. One 20-lb., dry chemical; fire rapidly extinguished. No flash-back due to concentration of chemical in fire area from weight of same. Twenty pounds of chemical used.

3. Low-velocity fog head with 10 ft. applicator, 100 psi. nozzle pressure. Fire immediately extinguished; entire surface covered with a dense steam blanket; no flash-back.

4. Repetition of No. 3, applying fog to one-half of fire surface. Fire was extinguished, but time extended due to reduction of steam volume.

5. Low-velocity head with 10-ft. applicator, discharging fog-foam supplied by 60 to 120 gal. foam liquid proportioner. Fire extinguished when area blanketed with steam; no evidence of foam on surface; water content of fog-foam extinguished fire.

6. One liquid foam nozzle supplied as in No. 5. No effect on fires; no evidence of foam. Fire finally extinguished with low velocity fog.

7. Saturated steam applied through 1½-in. hose line and hose nozzle with ⅝-in. solid stream orifice. Not effective due to surface agitation; fire finally extinguished using low velocity fog.

8. Saturated steam applied with low velocity L-11 head with 10-ft. applicator. Fire extinguished and further demonstrating need for simultaneous surface blanketing.

9. Balance of H_2SO_4 and Light Ends poured into tank and allowed to burn out to evaluate result of permitting a refinery tank to burn out with only exposure coverage. A black foam-like substance, apparently "coke," formed on the surface of the liquid and eventually slopped over tank edge was readily extinguished with Class A methods. This "coke" constitutes a hazard in that it plugged the normal drainage system at the refinery fire, making it necessary to wade through several inches of H_2SO_4 over a very wide area.

As a result of the tests it was reported by Navy authorities that employment of low-velocity fog of finely divided water is an effective extinguishing medium for refinery fires of petroleum oils containing any considerable volume of sulfuric acid.

No Explosions

No explosion occurred during the actual or test fires. However, the hazard of confined inflammable gas mixtures must be especially considered with this type of fires, it was stated. Greatest hazards to personnel, it was felt, would be from contact with the concentrated acid or from exposure to gases. Self-contained breathing apparatus, rubber boots and suitable clothing were advised for personnel.

The Damage Control Training Center at Philadelphia suggested that the portable foam applicators now used in refineries be supplemented by the addition of multiple water inlets and a large volume, low-velocity, finely divided fog nozzle. Such a device could be used for fog-foam, or fog, and would lend itself to wide application in providing fire protection.

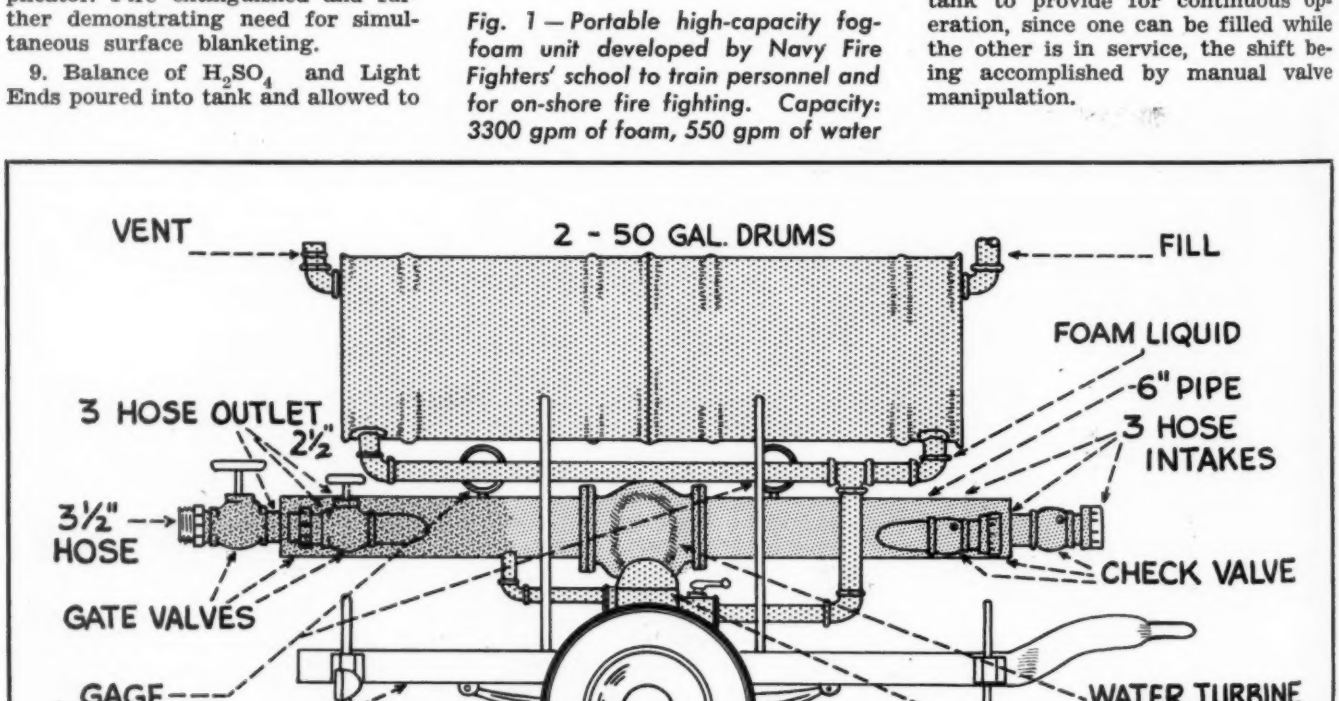
Navy's Portable Unit

The Navy's portable fog-foam unit brought to the Philadelphia fire is shown in Fig. 1. It consists of two 50-gal. tanks mounted upon a trailer in conjunction with a foam liquid proportioner driven by a water turbine. Water must be supplied to the unit from an outside source at a pressure of approximately 100 psi.

Incoming water is received through three 2½-in. connections to a 6-in. pipe connected to the inlet side of the water turbine. This drives a positive-displacement foam liquid pump which draws the foam from either of the two 50-gal. tanks. Discharge side of the water turbine is connected to the same 6-in. pipe into which the foam liquid pump discharges.

The foam solution is taken off the 6-in. discharge line through either of two 2½-in. outlets for hand lines or a single 3½-in. outlet for a monitor. Pump and turbine are so sized that discharge from the unit will be 6% foam solution and 94% water. Fill connections are provided on each foam tank to provide for continuous operation, since one can be filled while the other is in service, the shift being accomplished by manual valve manipulation.

Fig. 1 — Portable high-capacity fog-foam unit developed by Navy Fire Fighters' school to train personnel and for on-shore fire fighting. Capacity: 3300 gpm of foam, 550 gpm of water



Fuels of the Future

TWO comprehensive studies, on trends in utilization of fuels as energy sources and on the availability of various forms for our future needs, were reported to the meeting on "Fuels of the Future," in Chicago Nov. 10, under the auspices of the API Division of Refining. Together the two papers make a blueprint for long-range technological developments in refining.

Most essential utilization is of liquid fuel for transportation, to be supplied by petroleum through the foreseeable future, the paper by W. M. Holaday of Socony-Vacuum Laboratories and his associates points out. Great possibilities exist for improving the efficiency of utilization in automotive equipment. To the extent this is achieved by improvements in design refiners may be spared the need to produce the more costly fuels which would in themselves make possible increased engine efficiency. The second paper, by Professor Walter G. Whitman of MIT, presents a program for insuring liquid fuel supplies against a future national emergency, and indicates the technological trend in refining which should parallel this program.

In view of the importance of the two papers to refiners, both for their reading and for filing for future reference, they are published in full on the following pages.

PRESENTED BEFORE GROUP SESSION ON "FUELS OF THE FUTURE" UNDER THE AUSPICES OF THE DIVISION OF REFINING, 29TH ANNUAL MEETING OF AMERICAN PETROLEUM INSTITUTE, CHICAGO, NOV. 10, 1949

LIQUID FUEL SUPPLIES AND NATIONAL SECURITY

By **WALTER G. WHITMAN**
Department of Chemical Engineering
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This study of the probable requirements for liquid fuels in another war and the possible techniques for meeting them is based on the premise that the needs will be greater than in the last war and that they will increase during the war in about the same rate as in periods of peacetime prosperity.

Crude oil will remain the major source of liquid fuels for the next 30 years and methods for increasing its production in an emergency are emphasized. These include research to discover new finding methods, continued high exploratory activities, restricting production from new fields, unit operation of fields, specific engineering projects to step up production in the emergency, developing new areas like western Canada as defense reserves and stockpiling steel pipe.

The creation of a stockpile of liquid fuels as soon as a war emergency is evident is regarded as more practicable than storing large volumes in peacetime. The discussion of foreign oil concludes that we should import as much oil as can be accepted without serious prejudice to domestic exploratory activity. With the government assisting by basic research, the oil industry can be counted on to build synthetic liquid fuel plants when they are needed.

It is concluded that government projects to assure war supplies of liquid fuels need not extend beyond basic research, detailed planning for quick stockpiles and production increases when emergency comes, and modest prewar provisions for stockpiling steel and war specialties, principally toluene and aviation alkylate. Continuing close liaison between government and the oil industry in defense planning is essential.

AN adequate supply of liqud fuels is imperative to national defense. During the last war petroleum represented 60% of the tonnage shipped to the war theatres, and much larger volumes were used at home for basic transportation and other essentials.

Another major war would almost surely develop greater requirements once it was well under way.

This paper attempts to analyze the technological problem of liquid-fuel supplies in a future emergency, and to suggest means for reasonably assuring that the needs are met.

The time scale which is implied when referring to a "future" situation needs definition. In his stimulating paper on "Major Sources of Energy," delivered last year before this division, Eugene Ayres looks centuries ahead. By contrast, the able "Report on the Long-Term Availability of Petroleum," which is referred to later, restricts itself to the next 10 years. In the present discussion anything within the next 10 years is considered "short-term"; "long-term" implies a period from 10 to perhaps 40 years.

I—THE RESPONSIBILITY FOR SECURITY

IF we were certain of world peace, the United States could fairly rely on private enterprise alone to secure its liquid-fuel supplies for the indefinite future. Depletion of domestic crude reserves would have the effect of further encouraging domestic and foreign exploration and the development and construction of synthetic-fuel plants. The timing of these changes in source of supply need not be predicted far in advance, because the shifts would not be disruptingly rapid.

In contrast, the possibility of a major war introduces the complications and compulsions of national security. Timing becomes a dominant factor in assuring a state of readiness for emergency.

In the past few generations this country has enjoyed the privilege of living through the periods between its wars in a peacetime atmosphere and economy. Major wars started elsewhere, and we had time to readjust and to arm before engaging as participants. Our military forces were small, because we saw no need to pay high insurance premiums against the possibility of sudden enemy attack.

The current expenditure of some 15 billion dollars annually for a military establishment exemplifies a changed attitude. No longer do we count on having years to arm before coming to grips with an aggressor. The country feels that we must be ready, and it is willing to support policies and expenditures which are definitely uneconomic in peacetime save as insurance premiums against future war. Just as you and I do not expect to die tomorrow but we nonetheless carry life insurance as protection to the family, so the citizens of this country elect to pay premiums for preparedness against disaster.

If national security demands that actions be taken which are not sound investments for private enterprise, the people as a whole, through their gov-

ernment, must accept the responsibility and pay the cost. No company or group of companies can, or should, be expected to assume such responsibility and to bear such costs voluntarily in our competitive system.

However, the fact that government must finance the full expense of a military establishment, which is useful only to prevent or to prosecute war, by no means implies that an active industry which is devoted to supplying liquid fuels in peacetime may not be able to assume the burden of wartime supply without prior government participation in its operations. The principle that government has the responsibility for national security is inescapable, but the discharge of this responsibility may or may not require government expenditures in any given activity during peacetime.

II—WARTIME REQUIREMENTS OF LIQUID FUELS

NO one can foretell the number of barrels per day of liquid fuels which would be called for to meet basic requirements in a future war. However, the history of domestic consumption through the past 30 years discloses, rather to my surprise, that the last war period is not distinguished by any greater percentage increase in total demand than has occurred during healthy peacetime years. Thus over the 11-year period of 1919 through 1929 total domestic consumption grew rather steadily from 1.03 to 2.58 million barrels per day, approximating an increase of 9.6% per year before the depression checked demand; over the 4 years 1938 through 1941 it rose from 3.12 to 4.07 million barrels per day, an increase of 9.2% per year; and over the 4 war years of 1942-1945 it rose from 3.97 to 4.84 million barrels, at 6.8% per year. The postwar growth through the next 3 years (to 5.76 million barrels per day in 1948) corresponds to 6.0% per year. The same general conclusion is reached by examining the figures on world production of crude oil.

Of course, the war period brought rationing of liquid fuels, just as war naturally requires rationing of most basic commodities. When a nation strives to enlist its utmost productive capacities in support of its war effort, unnecessary consumption which diverts manpower, materials, facilities, and transportation cannot be tolerated. But few would contend that the war effort was appreciably impaired by oil rationing, and the record is clear that military needs were satisfied.

I must agree that another war may, if long continued, bring unsatisfiable requests for tremendous volumes of jet fuels to power combat planes and missiles. But civilian rationing can be far more rigorous that it was last time if it is well-planned in advance. And it is sobering to realize that Germany and its allies prosecuted an aggressive war for more than 5 years, with a peak production of less than 400,000 barrels of liquid fuels per day.

Considering the unknowns of time, place, the enemy, and weapons, I think it reasonable to assume that the requirements' goal in another war will be a production which increases above the prewar rate by the same percentage as would apply in years of peacetime prosperity. This concept may have to be modified with time. But, frankly, war plans based on any great excess over this total volume would appear to demand such excessive national expenditures, continuing for indefinite periods while a potential enemy may bide his time, as to debilitate seriously our economy. In a recent article entitled "A Program for World Peace" (*Oil Newsmagazine*, July 1949) James H. Doolittle discusses preparedness, and warns against its extremes with the statement: "We could easily destroy ourselves through the dissipation of our resources in being always ready."

The discussion of requirements has so far dealt only with total volumes. In addition, there will be insistent demands for special war products, e.g., aviation gasoline, toluene, and synthetic rubber in the last war, which will chiefly affect the refineries but which may have repercussions on transportation, and even on production. It must be realized that some specialty programs may be poorly managed at the start, as was the case with aviation gasoline and rubber until some months after Pearl Harbor. Such mistakes will result in subsequent "crash" programs, conflicting for high priority with technological developments like the atomic bomb which are not predictable prewar. Coordinated industry-military planning will minimize these "avoidable" crises and their drag on war production.

Before ending this section, it is pertinent to differentiate between the use of the word "requirements" in an economy of peace as against one of war. In war, "requirement" means the absolute need for a product because of its contribution to the integrated war effort. A scale of essentiality must be established by overall planning. On this scale, which will, of course, change with condi-

Through training and experience, Professor Whitman is well qualified to make the accompanying objective study of the nation's liquid fuel requirements in case of another war and the means available for their supply.

A graduate with a master's degree from Massachusetts Institute of Technology, he served on the research staff of Standard Oil Co. of Indiana from 1926-34, being assistant director for the last four years. In 1934 he was appointed head of MIT's Department of Chemical Engineering, which position he has held since, as well as being in charge of its program of engineering practice schools.

On leave of absence during the war, he joined the War Production Board in Washington, where he was in charge of all basic chemicals. He was also chairman of the Sub-committee on Aircraft Fuels and Lubricants of the National Advisory Committee for Aeronautics, chairman of a special OSRD committee to report to the services on long burning propellers for missiles, recommended techniques for improving the range of combat aircraft, and served as a member of a U.S.-Canadian Ordnance Committee on Production of Explosives.

Professor Whitman is widely known for his scientific contributions in the fields of corrosion and absorption of gases by liquids, the latter of which has led to improvements in design and operation of processing units in several industries.

tions, a 10% increase in diesel fuel for domestic railroads might at times be more essential than a 10% increase in jet fuel for planes, and priorities for some new secret project might override both.

When the word "requirement" is applied to a peacetime situation, it has a quite different meaning—representing the total amount which people are willing to buy at existing prices. Some of the total represents a real need which cannot be satisfied in other ways, whereas some of it is merely the amount which can be sold in competition with other materials of equivalent usefulness.

Summary on Requirements

The absolute requirements of liquid fuels for a war in the unknown future, including essential civilian and indirect military, are indeterminable. However, the constantly increasing importance of liquid fuels to our daily living and the expanding plans of the military for power plants which consume ever greater amounts of fuel, particularly in the air, indicate that requirements would become much greater than in the last war. The assumption that war requirements will bring an increase over the prewar years which will approximate the percentage increases which characterize prosperous peacetime periods is supported by the record of the last war and, in my opinion, is the most realistic approach at present to the problem of total liquid-fuel requirements. Meeting such needs within the inevitable wartime restrictions of manpower and materials may indeed prove a tremendous challenge.

III—SUPPLIES

THE problem of assuring supplies on a scale which will meet war requirements has enlisted much thinking by industry and government, and has elicited such diverse suggestions as stockpiling products, importing crude, creating government crude-oil reserves, constructing synthetic-fuel plants, and prewar rationing. It is my purpose to analyze various techniques which might be considered, viewing them in their relationship to national security. The problems are much too complex for any one individual adequately to comprehend and judge. Perhaps my chief qualifications for such a study are experience in petroleum refining, service with the War Production Board in the last war, and what I hope is a relatively objective viewpoint.

A. General Considerations

The significance of timing stands out in any broad consideration of national security. If we knew when and where we would be attacked many questions would be readily resolved. But a program which concentrated on preparation for a war within the next 4 years might well embody policies and actions which would prejudice our security if the war were to come 25 years from now. For example, to what extent should we conserve our crude resources by reducing wasteful practices in consumption as well as in production, by discouraging marginal uses, or by importing large volumes of foreign crude, in order to have a stronger resource position 25 years from now?

Timing is also a dominant factor in planning specific measures for meeting war requirements. There may be large fields of recoverable oil under area "X" which would be useful in war; but, if the region has not been well prospected before war breaks out, the chances that they will contribute in the emergency are almost negligible. On the other hand, a field which is only partly developed at the beginning of a war may be susceptible to rapid development and important production within the next year or two.

The oil industry is very alert and responsive to short-term trends. Ever-changing forecasts of demand and supply for the near future must guide the day-to-day decisions of the many units in a highly competitive business. It is significant that the industry is always verging on a shortage or an oversupply of products, as is well illustrated in the history of the past two years. Just as the individual is stimulated to greater accomplishment when he lives in a changeable and unpredictable climate, so the oil industry's vigor and flexibility are due in considerable measure to its restless economic climate. But the tenseness which characterizes the industry's daily operations tends to relegate to the background long-term considerations.

B. Characteristics of Crude Production

When one considers raw-material supplies for liquid fuels in an emergency within the next 30 years, it is apparent that crude oil will be the mainstay, if not the total source. The question of crude supply is, therefore, of paramount significance; and a good deal of the study in preparing this paper has been on the nature of the producing industry. Before this audience of refiners it seems pertinent to discuss certain characteristics of crude finding and recovery which bear upon the probable production in an emergency, and how it might be increased.

Oil production has two major tasks, viz.: finding oil and recovering it. As refiners, it is well for us to realize that more than half the investment and more than half the operating costs of the oil business are in production.

Domestic Reserves

The API Committee on Petroleum Reserves estimates our proved domestic reserves at the end of 1948 as 26.8 billion barrels of total liquid hydrocarbons (23.3 billion barrels of crude and 3.5 billion of natural-gas liquids). It has been customary in the industry to divide the year-end reserve figures by the crude production for that year to obtain a figure which is known as "years' supply," or number of years of proved reserves. This ratio has varied between a maximum of 17.7 in 1919 and a minimum of 10.4 in 1923. For 1948 it shows 12.2 years.

There has been much misunderstanding and misuse of the committee's figures. Its report explains that the estimates "refer solely to proved or blocked-out reserves—recoverable under existing economic and operating conditions." For example, the reserves credited to a new field brought in by a wildcat well during 1948 would usually be calculated only over a small area which could be regarded as proved. Development of the field in subsequent years might "prove" many times the amount of oil which was credited to the field when it was first discovered, and the addition would be included in later years as "extensions." Similarly, an increase in probable recovery from a field because of the installation of secondary-recovery facilities, or because the price of crude went up and thus postponed the abandonment of stripper wells, would be reflected at the time by adding reserves under the heading of "revisions."

It seems reassuring for future supplies that the proved-reserve estimates have increased by 2.8 billion barrels in the past 2 years, despite high production rates. Yet the optimism generated by these figures may be unjustified; i.e., 89% of the new reserves were derived from extensions to known fields and revisions of previous estimates. As is always the case, the true extent of the new discoveries is as yet unknown, and it will take perhaps another five years before development of the new fields will be sufficient to permit a reasonable appraisal.

During the war the Petroleum Administration for War tabulated new discoveries in a different manner by crediting revisions and extensions back to the year when the field was discovered. This method, based on information available in 1948 and ap-

plied to the years 1935 through 1942 (*Petroleum Data Book*—2nd edition) credits those years with about 3.6 times the volume of new discoveries which the API committee ascribed to them just after the year of discovery. If this multiplying factor of 3.6 were applied to the API committee's estimate of new discoveries in 1947 and 1948 (966 million barrels total liquid hydrocarbons), it would indicate new finding of only about 3.5 billion barrels, as against production during those 2 years of 4.2 billon barrels.

Probably no great reliance can be placed on this method of extrapolating the results of recent discoveries of new fields beyond the conservative "proved-reserve" figures of the API committee. We must accept the fact that you cannot tell for some years how much oil has been found when a wildcat brings in a new field.

The cost of finding new oil is steadily increasing. Exploratory costs, which totaled about a quarter of a billion dollars annually in the prewar period, are now running well in excess of a billion (Struth, *Petroleum Engineer,* January 1949). Oil is progressively harder to find, and requires more scientific effort and deeper drilling. Drilling costs, which make up about half of the total, increase about with the square of the depth; thus, a 10,000-ft. well averages about 4 times the cost of a 5,000-ft. well. Annual geophysical costs in the U. S. are estimated as 125 million dollars (Eckhardt, *Oil and Gas Journal,* March 17, 1949); geological expenditures may be almost as high; and land and lease expenses are estimated at around two to three hundred million. Incidentally, about 10% of the area of the U. S. is under lease by oil interests.

Producing Capacity

Proved reserves are the source of production, but they do not tell how fast the oil can be produced. Rate of production is a complex problem which involves field and well characteristics, economics, state regulatory commissions, and human nature.

The East Texas field, for example, has been producing for many years under close control to hold bottomhole pressure at not less than 1,000 psi. and thereby avoid gas evolution in the formation. It produces almost 2 barrels of salt water per barrel of oil, 90% of the water being pumped back and helping to maintain the water drive. Under these conditions, East Texas produces around 300,000 barrels of oil per day, or a little less than 5% annually on its estimated remaining reserves of 2-1/3 billion barrels. Many fields can be operated efficiently at a higher rate of exhaustion; others are operated at high rates regardless of efficiency. The average rate for the country as a whole is about 8% per year.

One of the challenging problems of oil production is to determine the proper rate for withdrawing oil from a field, with due regard to economics. Reservoir engineers have developed a concept known as "maximum efficient rate" (MER) (Edgar Kraus, API 28th annual meeting, Nov. 11, 1947) which takes into consideration the effect of rate on ultimate recovery and economic return from the field. A proper MER establishes a ceiling for production rates which should not be exceeded. Actual rates may, of course, be less than this ceiling to conform with market requirements.

It should be emphasized that the "maximum efficient rate" for a pool is not some fixed characteristic of the pool alone, but is affected by many variables which may change with time; e.g., well spacing, unitization, operating costs, income from the field, secondary-recovery techniques like pressure maintenance and water injection, and other engineering adjuncts which may become justifiable under changed conditions. The MER for some pools is easily determined and, therefore, readily agreed upon by different reservoir engineers; but many pool analyses develop sharp differences of expert opinion.

When one speaks, therefore, of the total "maximum efficient rate" of all the producing fields in the U. S., it must be recognized that the summation includes many pools which are not properly rated, or which are not rated at all. With this qualification, it seems probable that the "total" MER of U. S. fields was equivalent to the crude production late in 1948, or about 5.6 millions of barrels per day of crude (exclusive of natural-gas liquids) at that time. Today it should be close to 6 million barrels because of additional well completions, which would more than balance declines in the intervening period.

Constant drilling of new wells is essential. One way of considering it is to say that, on the average, we should find enough new reserves each year to balance the year's production and also to provide the base reserve for any increase in production next year which may be necessary to meet expanding demand. Thus, if 5% greater production is desired next year, the findings per barrel of oil consumed should be 1 barrel of replacement oil plus enough more oil reserves to permit 0.05 barrels more production. Assuming the country average of 8% annual production on reserves (which perhaps exceeds MER), the extra 0.05 barrel to be produced will require finding about 0.6 barrel of new reserves. Therefore, the total desired finding would be 1.6 barrels per barrel produced.

Another way of visualizing the need for new findings is to regard it from the standpoint of production rates. If no new wells were drilled, and if all present fields operated at their MER's, the MER of the country as a whole would decline about 8% annually. Again assuming a 5% increase in desired production, the wells now in existence would produce only 88% of the desired amount next year; i.e., 12% should come from new wells. Of course, if demand were not up to the MER of the country, the decline would be less.

The Petroleum Administration for War made some interesting estimates on this point, and concluded that the efficient productive capacity of the country would have dropped almost 30% in the 44 war months to V-J day if there had been no drilling after Pearl Harbor. The calculated percentage drop would presumably have been greater except that total demand was below efficient productive capacity in all but the last year of the war and, hence, production was not pushed to capacity in the earlier years.

PAW made another estimate which assumed that there was no exploratory drilling after Pearl Harbor, but only that which allowed for the actual drilling of development wells in producing fields. On this assumption, the calculated loss of efficient productive capacity over the same war years was 16%.

Timing of Discovery and Development

The intensity of the search for oil is closely related to the anticipated profits from its discovery. Strong demand and high prices for crude greatly stimulated all phases of crude finding in 1947 and 1948, when the number of seismic crews increased to 500 and the number of exploratory wells drilled jumped to a record 2-year average of 11,600 per year, which is about double the average drilling rate for the 5 years before the war.

The process of finding and developing oil pools involves a time lag which is comparable to the time needed to develop a new refining process from small-scale laboratory research to successful commercial operation. Geological work, followed by geophysical activities with the gravity meter, the magnetometer and, finally, the seismograph, determines the most likely spots for wildcat drilling. One does not embark lightly on drilling even a 4,000-foot wildcat, and the deep ones cost anywhere from a quarter of a million dollars up; 90% of the exploratory drilling sites today are selected on the basis of technological appraisal, and yet only 20% of such exploratory holes are producers. In comparison, those sites which are picked without benefit of technology average only 6% success. From three to five years of geological and geophysical study in an area, accom-

panied by extensive land-leasing activities, is common before a wildcat is drilled.

Wildcat wells take more time to drill than wells which are developing a proved field. The formations and conditions to be encountered are less known, and many data must be taken and decisions made as drilling proceeds. It must not be thought that a dry wildcat is a total loss in the search for oil. The data obtained in its drilling increase knowledge of the area and aid markedly in defining the best location for the next wildcat or for transferring efforts elsewhere.

The time required for drilling wildcat wells is short in comparison to the three to five years of preliminary exploration and analysis of data which went into selecting the site. However, so many wildcats prove to be dry that a time allowance of one year between the decision to drill and the finding of oil is a fair approximation.

Subsequent development of a newly discovered field by drilling proceeds at a rate which is greatly conditioned by the demand for its oil. Many West Texas and Rocky Mountain fields could not advantageously be developed for many years. On an average, it may take three to five years to develop a field to reasonably full capacity, but in an emergency this could probably be reduced to a year if the drilling equipment, supplies, and manpower were available.

Summarizing this analysis of the time factor, it takes on an average some 7 to 10 years to obtain reasonably full development of a new field from the time when exploratory studies of the area are initiated. The preparatory work, particularly that of seismograph crews, is necessarily slow, and requires highly trained personnel. Those of you who are engaged in new developments in refining technology will recognize the time analogy between a new process or product and a new oil field.

Reserve Producing Capacity

Reserve capacity to produce oil beyond immediate demand was normal in this country before the war. During 1941 we had about 900,000 barrels per day of surplus capacity within efficient producing rates; in fact, the production capacity of the country was not really challenged until the middle of 1944, despite subnormal drilling in 1942 and 1943. Transportation, rather than producing or refining, limited output, and military consumption developed at a relatively slow pace. We can fairly anticipate that the increase in demand would come more quickly in another war, and that reserve capacity should be exploited at once to fill product stockpiles, as discussed hereinafter.

From 1944 until 1949 the reserve capacity has been negligible, chiefly because exploration and field development did not keep up with demand during the war and because steel continued to be short, postwar.

Today we apparently have a U. S. capacity at "maximum efficient rates" of around 6,000,000 barrels per day (not including another 450,000 barrels daily of natural-gas liquids). This means a reserve producing capacity of almost a million barrels a day. Total capacity is constantly changing—tending to decrease as present wells decline and stripper wells are abandoned, and to increase as new wells are drilled in existing fields, the limits of present fields are extended, new fields are discovered, and improved operating techniques like pressure maintenance and water injection offset declines. It is a startling fact, illustrating the necessity for continuous expenditures to find and to produce oil, that more than 40% of our total producing capacity today is from wells which have been drilled since the end of the war.

It should be noted that the true measure of reserve producing capacity is not merely the added production which could be obtained by opening up existing wells. Behind this immediate reserve are the fields which could be developed rapidly by emergency drilling. And, to a lesser extent, the existence of a large store of exploratory information which indicates likely prospects for wildcatting contributes to the reserve capacity to produce in time of need. Producing companies normally have enough promising locations for exploratory drilling lined up to keep their drilling rigs busy for a year or more.

This picture indicates a considerable flexibility in productive capacity, depending upon the demand for crude oil. Over a period which is short in terms of national security—5 or 10 years—producing capacity is closely related to the amount of exploratory and development activity of the years just preceding. If the prospects of profits are good, such activity will be high. On the other hand, if the preliminary phases of the search for oil—basic research on better methods for detecting the existence of pools, scientific prospecting, and wildcatting—were curtailed by conditions which discouraged exploratory and development enterprise, capacity might hold up for a couple of years, but would then begin to drop.

C. Stockpiles

Stockpiles of basic essentials are a tremendous asset in war. A larger stockpile of natural rubber before Pearl Harbor would have taken the extreme urgency off synthetic-rubber production and thereby would have benefited the overall war effort.

Stockpiling need not be restricted to imported materials. With domestically produced materials it often can be instituted effectively as soon as an emergency is evident by a process of strict rationing and the elimination of less essential use, at the same time calling for maximum production and stockpiling the excess. Two examples from the past war will serve to illustrate this technique.

Soon after Pearl Harbor it became evident that large amounts of benzene would be required to make styrene for the synthetic-rubber program. Although the need was at least a year ahead, strict allocation of benzene was instituted at once, and its use in motor fuel was prohibited. Almost two-thirds of the country's benzene production thereby became available for stockpiling, and a healthy reserve for the rubber program was established before styrene production got under way. Subsequently it developed that the aviation-gasoline program required benzene to make the additive, cumene. By a combination of maximizing production and drawing on the stockpile, this need was also met in full.

Industrial alcohol affords a parallel illustration. The production of butadiene for synthetic rubber was originally planned on the basis that the petroleum industry would provide most of the butadiene but that about a third would come from plants which used alcohol as the raw material. The prospective requirement for alcohol far exceeded the capacity of the regular industrial-alcohol plants; therefore alcohol was put under allocation, and all the whiskey distilleries were converted to industrial-alcohol production. When the alcohol-butadiene plants swung into operation in 1943, the alcohol stockpile was sufficient for eight months' feed for all three projected plants at rated capacity.

This proved to be most fortunate; for it turned out that alcohol-butadiene had to carry the lion's share of the butadiene program, producing more than two-thirds of the amount used in synthetic rubber through the crucial period of 1943 and 1944. Incidentally, these alcohol-butadiene plants actually developed almost twice their rated capacities, with a correspondingly increased appetite for alcohol. Without the advance stockpiling to supplement maximum current production the needs for the rubber program would not have been met.

The same technique of rigorous rationing or allocation when the emergency is evident and the creation of a stockpile before essential war consumption has developed should be applicable to petroleum. To do it, there are two essentials:

1. The allocation or rationing program to eliminate less essential use

should be instituted promptly when the emergency becomes evident.

2. Tankage must be available to receive the excess of production over the allocated supply and thereby build the stockpile.

These two steps call for thorough and realistic advance planning. It would be futile to restrict civilian usage if this merely meant that crude production and refinery runs had to be reduced because all tanks were full. The object is to build as big a stockpile as possible against future demands, not to be rough on the civilian.

As a rough prognostication, such a stockpile might receive at least 20% of the country's production for an equivalent of 10 months. At current rates this would create a stockpile of 360 million barrels in the first year of the emergency. (Note that this figure is more than twice as large as the present difference of 150 to 160 million barrels between "low" stock and "high" stock inventories in industry tankage.) A stockpile of this magnitude can play a vital role in a war program, supplementing inadequate production later on when demands become heavy while production capacity is being enlarged.

Again referring to the timing factor which so frequently enters security considerations: It would be essential to have a part of the necessary tankage ready before the emergency is evident; 150 million barrels of empty tankage, costing about 200 million dollars and located strategically to receive refinery products by short pipe line, might be adequate in advance. It should be understood that this is not a prewar stockpile of military products, but is empty tankage, ready to receive the "first fruits of rationing." Additional tankage could be erected in time if its location and construction were planned beforehand.

The question of what should be stockpiled does not seem to be too important, except that it should be products which will be essential to the war program. The two least desirable stockpile items are crude oil and residual fuel, i.e.: crude, because its stockpiling does not help to keep refineries running at maximum capacity from the start; and residual fuel, because its yield can be increased at any time without strain on refineries. The most desirable products would be those which are going to require the most effort to produce in the desired volumes.

In contrast to this program of stockpiling when the emergency starts, oil products might be stockpiled during peacetime years in anticipation of an emergency. One scheme which has had some consideration is to refine and store the products from an extra half-million barrels of crude a day for perhaps five years. In such a program the stored products should, of course, be kept reasonably fresh by withdrawals to market and replacement on the principle of first-in-first-out. The proposal has the merit of creating reserve capacity in refining as well as in crude production while the product stockpile is being accumulated. It would, however, represent a tremendous expense for government to acquire and store 900 million barrels of products at a probable cost, with tankage, of more than 5 billion dollars, and presumably to retain this stockpile indefinitely pending a war emergency. Stockpiling of such volumes of oil aboveground in peacetime appears to be an unnecessarily extreme solution compared to other possibilities.

On the other hand, some prewar stockpiling of especially urgent war products which require considerable processing would be advantageous both in creating the reserve stock and in keeping activated a core of the necessary refining facilities. Toluene and aviation alkylate are products of this type which might well be stocked in moderation during peacetime, perhaps to the extent of two or three months of anticipated demand. For toluene, this might mean a million barrels; and, for alkylate, 20 million barrels.

D. Imports

In recent years the proved reserves of crude outside the U. S. have been greatly increased, largely as a result of American enterprise. South American proved reserves, chiefly in Venezuela, are some 10 billion barrels. The Middle East has proved perhaps 33 billion, or more than the U. S. total.

Canada which is now credited with only 0.5 billion barrels, is expected to prove anywhere from 5 billion up to 20 billion in the next 15 years. However, in a war emergency, Canada and the U. S. should be treated as a unit because of geographic proximity and the similarity of interests and political philosophy, and Canadian oil can, therefore, be classed with domestic oil in security planning.

The import question is today most controversial, and I shall restrict my comments to its effects on national security.

Present plans for Middle East oil development are limited to meeting requirements of the Eastern Hemisphere, notably our European allies of the North Atlantic Pact. It is displacing Venezuelan oil from Europe on a straight economic basis because of lower costs at the port of loading, despite a transportation disadvantage of about 50 cents per barrel to Atlantic ports in Europe. Therefore, Venezuelan oil which has been going to Europe, to the extent of almost 500,000 barrels per day, should be readily available to us, above the 400,000 bbl. or 500,000 bbl. per day which we have been receiving. Such oil would logically be refined near the big consuming areas of the East Coast, increasing this district's proportion of the country's refining capacity.

There are two security arguments against importing as much as a million barrels per day from South America, both bearing on the short-range aspects of security:

1. A major war might well stop the flow of Middle East crude, and our European allies would then need an equivalent amount from South America—thereby diverting practically all our imports of South American crude to Europe, and requiring an equivalent production increase in North American crude. However, if we do not accept South American imports in peacetime, it is quite possible that they would not be available for diversion to Europe in a war emergency. (It is, of course, conceivable that enemy submarine action might prevent any Venezuelan crude shipments either to Europe or to North America, but in such a contingency the sea lanes would also be closed to extensive overseas military operations, and the attendant large military consumption would not exist.)*

2. Imports will reduce the demand for domestic crude and, thus, reduce the incentive for exploratory activity in this country. This would adversely affect our productive capacity within a very few years, although it would leave us with greater domestic reserves for the more distant future.

The import issue points up a conflict between short-term and long-term security. Heavy imports today, although they would not prejudice security for the next year or two, might impair our domestic potentialities 5 or 10 years from now because of their withering effect on domestic exploration. On the other hand, the long-range interests of the country would be served by extensive imports of crude, both by fostering a healthier world economy in which there would be less danger of war and by conserving our native resources for the security of the following generation.

It is pertinent to note that imports of heavy crude which are processed

*The logistics of transporting supplies to overseas war theatres are not treated in this paper. However, it is pertinent to note that: 1, South American oil is strategically well located to supply both Atlantic and Pacific operations, and did so effectively in the last war; and, 2, the movement of Middle East crude in peacetime requires a large tanker fleet, which is a strong security asset.

primarily for industrial and utilities fuel would have less effect on domestic crude economics than if the imports were of light crude for refining. Nevertheless, from the security standpoint, the effect is rather similar in nature in that the coal-producing industry bears the shock of market contraction. Contrary to popular belief, coal production is no more expansible in a short time than is oil, if as much, and the loss of coal markets results in abandoning mines which can probably never be reopened in an emergency, as well as in the contraction of coal-transport facilities. For equivalent daily production (in heat units), a modern coal mine requires less initial expenditure but much more operating labor than does the average oil field.

E. Synthetic Liquid Fuels

It seems fair to assume that there will be a heavy demand for liquid fuels for at least the next century or so; beyond that we need not be too concerned because, if science renders them obsolete, it will do so by providing something better. Liquid fuels are uniquely fitted to supply the energy for propulsion over the highways, the railroads, the seas, and in the air. For stationary energy units —such as homes, commercial units, industries, and power stations—they are merely another source of Btu's, usually more convenient than coal but less so than natural gas.

It also seems evident that some day the finding and development of enough crude to meet demand will become so expensive that the production of liquid fuels by synthesis will be equally, or more, attractive. How soon this will occur on a significant scale is speculative. It depends on four factors:

1. *The cost of producing new supplies of crude*: There is a considerable time lag in determining this cost because, as pointed out hereinbefore, we do not know how much crude has been found in a given year until many years later.

2. *The cost at which synthetics can be produced,* which is a function of technological development.

3. *Our willingness to import foreign crude.*

4. *The future demand for liquid fuels,* considering both the desire to use increasing amounts and the effect of their becoming more expensive.

Enough is known today to assure that liquid fuels can be produced from coals, from natural gas, from shale, and from other sources of carbon such as tar sands. Germany produced approximately 120,000 barrels per day, or 42% of the liquid-fuel supply available to her, by synthesis from coal during the last war. Alcohol from agricultural byproducts was used as motor fuel in some countries which were unable to get enough gasoline for essential needs during the war.

Synthesis from Natural Gas

The first commercial production of synthetics in the U. S. is expected shortly from the Hydrocol plant now under construction at Brownsville, Texas. The raw material is natural gas. This is combined with oxygen extracted from the air to form carbon monoxide and hydrogen. The resulting "synthesis gas" is then catalytically converted to liquid fuel and by-product chemicals in a modified Fischer-Tropsch process. About 7,000 barrels of liquid fuels per day are expected from this plant. The realization from the by-product chemicals will be a significant factor in the economics of the operation.

Synthetics from natural gas will probably not be an important contributor to our future liquid-fuel supply. Natural gas is a very superior fuel on its own when it can be brought to market economically. It has had very low value at the wells in the Southwest because of the long distance to densely populated areas, such as the East Coast, and the relatively few gas-transmission lines. Today there are several major pipe lines from Texas to the East Coast, and one to California; and others are building or planned. Texas gas can be delivered from the pipe line in New York at perhaps 30 cents per 1,000 cu. ft., equivalent on a Btu basis to residual fuel oil at $1.80 per barrel, and to eastern bituminous coal at $7.50 per ton.

Such a setup certainly encourages natural-gas pipe lines to supply the centralized quality-fuel markets in competition with distillate oil and coal for space heating, and to spill over into industrial and utility plants (displacing oil and coal) to the extent that the fluctuating demand for higher quality uses does not utilize the full capacity of the pipe line. Further, by displacing or enriching manufactured gas, natural gas reduces the use of oil for gas manufacture, a field in which oil has greatly encroached on coal. This is an interesting example of inter-fuel competition.

It appears that natural gas will in most instances have a higher value for direct use as a fuel than it will have as a raw material for making liquid fuels. Cases may be encountered where distance from market is so great that a large reserve of natural gas would preferably be converted to liquid for transportation to market; e.g., where tanker transport was readily practicable but a gas pipe line would be too expensive, or where local demand for oil in an area where there was plenty of gas but no oil would justify synthesis.*

Oil from Shale

Tremendous reserves of shale in the western states—primarily in Colorado —could be processed by destructive distillation to yield around 25 gal. to 30 gal. per ton of a low-grade oil which could then be refined, probably by hydrogenation, to desired products such as diesel oil, and even gasoline. The Bureau of Mines reports excellent progress in developing large-tonnage mining methods at its station in Rifle, Colo. Several organizations are working to develop a suitable shale retort, with emphasis on low water requirements because the region is semi-arid. Present thinking favors preliminary cracking of the oil at the retort site to improve its viscosity and pour point so that it can be pumped to consuming areas like the West Coast for refining.

Estimates of the oil recoverable from shale reserves in western Colorado run up to 200 billion barrels, i.e., more than the probable amounts of recoverable crude oil in the U. S. The progress which is being made in developing, mining, retorting, and refining methods has created considerable enthusiasm for shale oil as the first probable supplement to crude oil in the production of liquid fuels on a large scale.

Oil from Coals

Germany produced oil from coal, both before and during the last war, by hydrogenation and by the Fischer-Tropsch synthesis. As yet neither of these processes is economic in the U. S. because of the availability of petroleum. This is well illustrated by the fact that residual fuel oil, which would certainly be a better raw material than coal for producing gasoline by either hydrogenation or Fischer-Tropsch synthesis, competes with coal on a straight heating-value basis in large power stations on the East Coast and on the Great Lakes. Before coal becomes of interest as a raw material for oil, the refineries will have improved their processing of petroleum so as to produce higher yields of the more valuable distilled products and so as practically to eliminate the production of residual fuel for uses where it does not command a premium over coal. (Residual fuel oil has superior value for some

*Note that oil-transportation costs from a Gulf field to a utility in New York Harbor usually run about 55 cents per barrel (gathering, pipe-line, terminals, tanker-and-barge) or 8.7 cents per million Btu; whereas the cost of transporting natural gas by pipe line to New York, at about 25 cents per 1,000 cu ft. is 24 cents per million Btu delivered. The difference is primarily investment cost, which is about five times as great for the gas pipe line as for the tankers and accessory facilities to transport an equivalent amount of energy.

operations such as ship bunkering, open-hearth metallurgy, and apartment-house heating.)

Whereas coal will probably be the ultimate source of much of our liquid fuels, oil from coal will not be economic until major changes in oil refining and marketing, necessitated by the increasing cost of crude oil, have been pushed to the limit.

F. Availability During The Next Ten Years

The most competent published appraisals of liquid-fuel prospects for the next 10 years are in the "Report on the Long-Term Availability of Petroleum," prepared in November 1948 by a subcommittee of the API National Oil Policy Committee, under the chairmanship of L. F. McCollum. Its major conclusions, predicated on the existence of favorable economic conditions for private enterprise and assuming that crude production will not exceed maximum efficient rates, may be paraphrased as follows:

1. The availability of natural liquid hydrocarbons (crude petroleum and nautral-gas liquids) produced in the U. S. will have increased by 1953 to 6,960,000 barrels per day, plus or minus about 5%, as compared to a 1948 estimated domestic production rate of 5,900,000 barrels daily (5,500,000 barrels of crude and 400,000 barrels of natural-gas liquids). Detailed estimates of domestic availability beyond 1953 are not warranted, but the committee does not anticipate a significant decline from 1953 to 1959.

2. Production of crude in the Western Hemisphere, outside the U. S., is expected to increase from 1,750,000 barrels daily in 1948 to 2,490,000 barrels in 1953, and in the Eastern Hemisphere (exclusive of Russia) from 1,500,000 barrels daily to 2,520,000 barrels in 1953. Both foreign sources are expected to increase further in the subsequent 5-year period and to represent additional supplies available to the U. S.

3. Production of synthetics will be almost negligible through 1953; but operable processes have been developed, raw materials are available in large amounts, and the inception of significant production is contingent only upon the economic justification and the time for constructing facilities.

4. Larger quantities of natural gas will supplement liquid fuels.

IV–DISCUSSION OF SUGGESTIONS

THESE considerations of liquid-fuel sources lead naturally to a discussion of various proposals for meeting the demands of a war emergency which I have encountered or developed in preparing this paper. My conclusions are summarized later.

There is rather general agreement that a vigorous and flexible oil industry, accustomed to quick adjustment to changing conditions, is the first essential. Its representatives should have a continuing active liaison with government, so that the country's state of readiness in fuel supplies is known to both. We cannot again afford the uncertainty, the misunderstanding, and the fumbling which characterized the military's early handling of petroleum problems before industry personnel had been effectively enlisted in government in the war.

There is also general agreement that government should finance specific measures for security in liquid fuels only to the extent that they are found necessary, but unsound ventures for private enterprise.

A. Suggestions Dealing With Reserve Production Capacity

The existence of a substantial North American reserve capacity to produce and refine crude oil at any time would offer the best physical assurance of liquid-fuel supplies. Many of the suggestions to be examined deal with this problem.

1. Developed oil fields which had been operating at low capacity or had been shut back, and which could be opened up at once in an emergency, would be ideal from the security standpoint. Several Texas fields, e.g., Friendswood, Conroe, and Hastings, exemplified this security ideal last time. But private capital cannot afford to bury money in developing new fields which it does not expect will show a return in the form of oil production until a war. Hence, the existence of this type of private excess capacity may be fortuitous—resulting from competitive enterprise's overshooting the mark in preparing for future demand. However, the expanding characteristics of the oil industry, which delivers products to almost every family in the country and which will go to extremes to satisfy its markets, means that some such overcapacity is normally expected.

It has been proposed that government pay the insurance cost of maintaining capacity in reserve by offering to buy fully developed oil fields which would then be shut down or operated under lease at very low capacity. Complete control of the pool would, of course, be essential. This would be an extension of the policy exemplified by the Elk Hills Naval Reserve, except that the pools would already be developed for quick production rather than held in an undeveloped and "unready" condition. (If such government reserves were acquired, they should be held for general wartime use, and not regarded as the property of one specific department.)

This concept of government reserve fields purchased from private owners (if more than half the interests wanted to sell) has been advanced as a balance against the effects of heavy imports. If government acquired and then shut back domestic fields which could produce substantially as much as our net imports, we might achieve the long-range advantage of conserving our own crude and at the same time protecting our fuel supplies over the short range against the loss of imports in war. Further, the market for domestic crude would remain strong, despite imports, because of government purchasing activity—thus maintaining the necessary incentive for active exploration.

But such a program would require heavy government investment. Thus, if imports increased to 2 million barrels daily, it might take something like 20 billion dollars to purchase domestic fields of equivalent producing capacity. The dollar investment should be sound enough because domestic crude oil will become increasingly valuable with time, but the implications of having government own almost half of our production capacity as a reserve are highly disturbing. Does the country have to pay such a price for insurance?

An alternate plan would be to leave field ownership in private hands and to have government pay a subsidy to the owners for shutting down the field for a fixed period of perhaps 10 or 15 years, unless war came sooner. The disadvantages of this scheme are similar in principle to those of government ownership.

Although some program of government purchase or subsidy for reserving "security oil" in domestic fields may merit thoughtful consideration a decade hence, it seems unnecessary to present planning.

2. Fields which have been discovered but not yet developed can play an important role in increasing war output if advance planning has provided for their rapid development when needed. Under the spur of competition in a healthy producing industry, exploration and wildcatting are stimulated by the desire to find new oil before a competitor finds it. But no such haste need dictate heavy expenditures to develop the newly discovered field quickly, particularly if it can be unitized. Slow development of new fields is a positive contribution to security if the plans and equipment for a rapid acceleration are ready.

Two suggestions have been advanced as to how government aid

might foster a slower exploitation of new fields if economic forces and allocation practices do not prove adequate:

a. The field might be developed with government loans, on an agreement which limited production to a low rate for 10 or 15 years. The loans would start bearing interest when the production restrictions of the contract expired.

b. The field might be left undeveloped by agreement, and with government subsidy paid as "in lieu" of royalty on deferred production.

3. An economic climate which is favorable to vigorous exploratory activities *before* the war is the necessary prelude to adequate capacity *during* the war. This implies healthy rewards for finding oil. Exploration and wildcatting are so characteristically individual competitive enterprises that active government participation or financing would seem most unwise.

4. Both federal and state governments can strengthen our security in liquid fuels by further fostering conservation in production, especially by encouraging unitized field operation. State regulatory bodies in the Southwest have contributed greatly to the cause of conservation, but much more remains to be done. Practices which result in greater eventual recovery fortify our long-range position. Equally important may be practices, contingent upon unitized operation, which permit higher efficient producing rates.

5. Better information on the country's efficient capacity to produce crude is essential to better security planning. The current program of the Texas Railroad Commission to hear testimony and establish "maximum efficient rates" for the pools throughout the state should stimulate similar efforts elsewhere. Perhaps this should be an industry task in those regions where state bodies do not take the initiative. More emphasis on MER's will challenge the reservoir engineers to greater accomplishment in the efficient utilization of pool reserves and capacity.

Production can be increased for a time by disregarding ultimate recovery and by producing to the maximum. We all realize that this would be done in a crisis. But it would seem utterly unsound to plan emergency production on a basis which involves seriously injuring our fields for the future.

6. Specific projects to increase the efficient rate of production from given pools might contribute significantly in an emergency.

As an example, the current MER of the East Texas Pool is somewhere near 300,000 barrels per day (about 5% of U. S. capacity). It has been estimated that the injection of 500,000 barrels of water from outside sources, supplementing the present salt-water return to the field, would permit the efficient production of another 250,000 barrels of oil daily from East Texas. The capacity of the present salt-water disposal facilities would, of course, have to be enlarged. This seems to be a case where the government could install facilities as an emergency reserve for increasing production rates in war without interfering with peacetime operations and private ownership. The expense would probably not exceed 60 million dollars, a cheap insurance premium for an increase of a quarter million barrels per day on demand.

Other projects of this nature to achieve greater emergency productivity can doubtless be developed. Some which are not economically justifiable in peacetime may yet permit greatly increased efficient rates which would warrant government construction for emergency capacity.

The question as to whether such government facilties to increase rates should be constructed or merely planned in peace is one of timing. If the specific plans and the necessary equipment were ready, installation might take only six to nine months. If that can be done, actual construction could be deferred until the emergency was evident.

7. The expectation of great oil development in western Canada warrants special discussion of its potentialities as a security reserve, Western Canada currently produces only 70,000 barrels per day, but various authorities estimate her probable reserves at between 5 and 20 billion barrels. Development of this huge region will probably be rapid at first, but will soon slow down. It is assumed that exploration and wildcatting will be vigorous over the whole area, but that field development will slacken after the first few years—awaiting the market demands which will justify development costs and pipe-line outlets.

Perhaps this natural process of letting things take their course is adequate. On the other hand, the usefulness of this oil when needed would be better assured if plans were made for quick production and transportation in an emergency. At a minimum, steel for field drilling and for pipe lines and pumps should be ready at the start of a war, destined for probable use in Canada. Possibly the preparations should go further. Promising fields which did not justify immediate drilling could be developed by government loans which would not bear interest until the fields went into production. Pipe lines could be constructed on the same basis. All phases of the problem of developing the potentialities of Western Canada would require study, with particular regard to the time factor. The possibility of a million barrels a day from this source when needed is reassuring, but we must be sure that it can be made available in time.

8. The last item under "reserve producing capacity" deals with steel—steel for producing and steel for pipe lines. Oil production was never really critical in the last war. But ocean transport proved vulnerable in the early months, and was taxed to the utmost by war-theatre demands throughout the war—and it took a long time to build the Big Inch and the Little Big Inch. We may fairly anticipate that next time there will be emergency pipe lines and much field development to be done (particularly in Canada or other new areas). If the line pipe, the pumps, and the oil-field goods are already available, the jobs can be done quickly. This means carrying inventories—inventories which in many cases may be larger than the oil or the steel industry can afford.

During the war we made tremendous amounts of ammonia. The country's capacity was more than doubled, and the plants required heavy pressure equipment like that in oil refineries. Yet the construction of ammonia plants never required top priorities and fights between competing agencies. Why? Simply because a certain ordnance officer ordered his heavy reaction vessels and compressors in the summer of 1939.

A stock of the most necessary steel items for the oil industry, carried by government to the extent that it exceeds normal industry requirements, should be excellent insurance against a shortage of liquid-fuel supplies. I suggest that government stockpile steel for oil production, pipelining, and refining when a slack develops in the demand for this type of product. Pipeline equipment is perhaps the most vital. At this point we cannot tell with certainty where it will be used. The flexibility of having the materials ready for use where needed is all-important. This is an essential feature of a program to assure a quickly developable reserve capacity and availability.

B. Suggestions On Stockpiles of Oil

1. The accumulation and storage of very large volumes of products—up to 900 million barrels—during peacetime as a maintained war reserve has been discussed previously herein. It is technically feasible, and it would stimulate the expansion of production, transportation, and refining during the years when it was being accumulated. It would be very expensive, however; and, in my opinion, it typifies a policy of "over-readiness," which is undesirable and un-

necessary if plans are laid to convert quickly to a war economy when the emergency becomes evident.

2. The suggestion of stockpiling urgent war products which require considerable processing falls in a different category. (The atomic bomb is a prime example.) In the last war there were only three important petroleum specialties of this character: toluene, the synthetic components of aviation gasoline, and the components of synthetic rubber. Moderate stockpiles of toluene and of aviation alkylate seem reasonable, largely as a means of keeping manufacturing facilities activated.

3. The oil industry seems to be trying to get along with too little product storage capacity for its regular business. The shortage of present industry tankage is indicated by comparing the low point on total stocks of crude, refined products, and natural gasoline with the high point of such stocks since December, 1946. Within this period there has been both a shortage threat, which aroused the industry to maximum efforts to avert it, and an oversupply condition, which resulted in reduced production and refinery runs. The low point on stocks was in March 1947, when the Bureau of Mines report showed 481 million barrels; the high was this summer, with 636 million barrels. The difference between high and low, representing the effective range of industry storage, is only 155 million barrels, or less than a month's supply.

A shortage of industry tankage would seriously hamper operations in an emergency. But this is not a case for government aid. It appears that the industry needs, and probably will provide, considerably more tankage for its regular operations.

4. It has been proposed that a reserve stockpile be created by importing and storing foreign crude. If it were to be stored aboveground so that it could be quickly available, the proposal corresponds to the product stockpile discussed previously herein except that the cost would be less, but there would be no peacetime stimulus to refinery capacity created by turning it into products. The suggestion that it be stored underground in depleted oil fields seems technologically less sensible than refining it for use as received and leaving an equivalent amount of producing capacity underground in our own oil fields.

5. The idea that liquid fuels should be rationed in peacetime as a move to conserve reserves has probably occurred at least once to most of us, usually after some irritating personal experience on the highway. But government restriction of fuel use is so repugnant to the free economy which we cherish, and it would so undermine the vigor of the oil industry, that it cannot be justified until the threat of impending war is clear and emergency stockpiling begins. Then the action should be prompt and decisive.

6. The most significant oil-stockpiling proposal seems to be to create a stockpile of products by quick and well planned action when the emergency becomes evident. Inasmuch as this has been discussed previously herein, it need only be repeated that rigorous rationing on a well devised plan should be instituted promptly, and that empty tankage, provided prewar at government expense, must be available to receive the first products for stockpiling while additional tanks are being erected.

7. This section on stockpiling would be incomplete without making a cross-reference to the value of stockpiles of steel for emergency pipe lines and for development drilling of oil fields.

In concluding the discussion of oil stockpiles, I feel that the storing of products or crude aboveground in large volume during peacetime in anticipation of a war in the indefinite future represents exorbitant and unnecessary insurance premiums for short-range security.

C. Suggestions On Imports

Suggestions on imports range all the way from welcoming large volumes, and thereby reserving some of our own crude, to prohibiting them so that domestic discovery and development will be stimulated to the maximum. DeGolyer recognizes both these considerations in his statement before the Armed Services Committee in February 1948: "My recommendation is that this nation import all of the oil that it can bring in without damaging its domestic industry, which is fundamental to it." The statements of the National Petroleum Council in "A National Oil Policy for the United States" emphasize protecting the health of the domestic industry by importing only as much oil as is needed to supplement domestic production.

No one individual can fairly determine the extent of imports which will best contribute to national security. In my view, short-range security in oil (over the next 10 years) may be impaired by heavy imports today, but longer-range security would be aided by a willingness to use larger imports than are now coming in. Eventually we shall want large volumes of foreign crude. To accept more now would lessen the shock of transition, and would have indirect but potentially powerful security benefits by encouraging world commerce and strengthening our allies. This is a broad policy issue which involves more than the single question of national security in oil. Restricting it to the oil security problem, I feel that the calculated risk of some sacrifice to short-term security, because of the probability that imports will be greatly reduced in war, is justified by the longer-term benefits of a stronger domestic resource position and a healthier world economy in petroleum.

A somewhat similar philosophy may be noted in the policies of the Texas Railroad Commission in reducing allowable oil production when market demand shrinks. Such policies indicate a belief that the long-range interests of the state and of its citizens are best served by temperate exploitation of its exhaustible wealth.

Suggestions that oil imports be used to build product stockpiles, or that government purchase domestic crude reserves in an amount equivalent to imports, have been discussed previously herein. To me, they seem like compromises involving government intervention which would be unnecessary if the industry can adjust itself to heavier imports without slackening its domestic exploration. A significant reserve of domestic producing capacity should be recognized as desirable and normal. It is well to remember in these days of surplus that only two years ago we were faced with a shortage.

D. Suggestions On Synthetics

General interest in synthetic oil—from natural gas, shale, or coal—has slackened somewhat in the past year because of the improved crude-oil supply position, but the basic importance of oil from other than crude petroleum is really unaffected. Synthetics offer a domestic supplement to domestic crude supplies and, therefore, a security factor which foreign oil cannot provide.

From the earlier discussion, it is concluded that natural gas will not become an important source for liquid fuel because it is more valuable as gaseous fuel. Coal has eventual promise, but not until crude availability has decreased to the point where residual fuel oil to compete with coal has been eliminated as a refinery product. Shale oil seems like the most immediate prospect.

Basic research on the problems of synthesizing oil is very much in order, both by industry and by government. As economic practicability becomes evident, private enterprise will assuredly embark on the large-scale development activities which are a necessary prelude to commercial operations.

Arguments that the oil industry

will hesitate to venture on the construction of synthetic plants because of the heavy investment required, and that security will thus be prejudiced, have led to the suggestion that government finance full-scale commercial plants which will be ready to operate in an emergency. Such a plan assumes either that the emergency will bring a sharp restriction in crude supply, because of loss of imports, or a sharp increase in requirements which cannot be met by rationing and quick stockpiling, or both.

Building a reserve synthetic industry, which must stand essentially idle if it is to fulfill its purpose as a reserve, is estimated today to require an investment of the order of 10 billion dollars for a capacity of 1,000,000 barrels per day ("Liquid Fuels from Coal and Oil Shale," by Roberts and Schultz, *Oil and Gas Journal*, September 15, 1949). For orientation on such big numbers, the aviation-gasoline program of the last war required a little less than one billion dollars in facilities, of which three-quarters was for industry-owned plant. A full-blown synthetic industry in idleness would indeed be expensive insurance.

The logical program for synthetics would seem to be for government to concentrate on basic research, and for industry to develop and install the plants as economic need justifies. It is pertinent to recall that the oil industry is venturing in excess of a billion dollars a year in the necessary search of new raw materials.

E. Suggestions on Refinery Utilization of Crude

Before this group it is not necessary to stress the refinery problems which are posed by security needs. Up to now I have mentioned the refiner's participation only by implication, as in the rapid building of product stockpiles at the start of a war, the modern prewar stockpiling of war specialties, the inadequacy of present industry storage facilities, and the expansion of East Coast refining to process imports. Of course, when a synthetic industry is built, it will be the product and the responsibility of the refiner. Also, reserve refining capacity is essential to security to almost the degree that reserve producing capacity is needed. It need hardly be mentioned that refineries to handle foreign crude should be on our own shores if we are to be fully assured of their contribution in a crisis.

But it does seem pertinent to discuss that aspect of refining which deals with yields.

The oil refiner attempts to process his crude oil in such a way as to secure the best net return from the sale of his products. These products can be classified roughly into "distilled" products, viz.: gasoline, kerosine, and distillate fuels; and "residual" fuel oil. Ideally, the refiner would like to maximize the yield of distilled products and not have to make any more residual fuel oil than is needed for quality uses such as bunkering ships. Actually, he is unable to do so because of processing limitations. "Resid" is a by-product.

As crude becomes scarcer and, therefore, more expensive, the refiner feels increasing pressure to secure more distilled product yield and reduce "resid" production. Crude oil will become too expensive to run it into a low-grade byproduct. Improved processing is essential to survival in the competition.

This economic pressure is favorable to the long-term security interests of the country. Excess production of residual fuel oil is a waste of quality resources almost like flaring gas in the oil field. (Note that this residuum is superior to coal as a raw material for synthesis to gasoline by either Fischer-Tropsch or hydrogenation processes). A number of processes for increasing distillate and reducing "resid" yields are operating today: coking, viscosity breaking, vacuum reduction, propane deasphalting, catalytic cracking, and even some hydrogenation. It is true that they require added refinery investment and operating cost, but these will be increasingly justified as crude becomes more scarce. Chester F. Smith ("The Future of Oil Refining," before the 14th Mid-Year Meeting of the API Division of Refining, April 6, 1949) concludes: ". . . . our large supplies of residual fuel oil should be considered first as a better potential source of light products."

There have been many times in the past when a refiner could with profit buy and run cheap crude directly into residual fuel oil, which he then sold by under-cutting the price of steam coal. (This is true today with heavy foreign crudes, although we are not directly concerned with them at this point.) A definite advantage of high crude price is that it discourages such uneconomic use of oil and tends to stimulate more efficient refining.

Fundamentally, that type of refinery development which increases the economic yield of products which have unique values as liquid fuels contributes to security by conserving a quality resource for quality use.

V—CONCLUSIONS

THE preceding discussion points up a conclusion which we all instinctively recognize: absolute security is a myth—we must choose between "insecure" alternatives. To me, the following measures seem most promising:

1. Foster the continuing existence of reserve capacity to produce crude in an emergency by:

a. Active research to develop new and better methods for finding oil.

b. High exploratory activity—incited by healthy rewards for finding oil.

c. Restricting production from new fields.

d. Encouraging unitization—which requires state and/or federal cooperation.

e. Securing better information on the country's existing capacity to produce—its true "maximum efficient rate" at any time.

f. Developing specific projects which will result in greater efficient production in an emergency as well as those which increase ultimate recovery.

g. Developing the potential western Canadian fields and other new domestic areas as emergency reserves until their production is needed for peacetime uses.

h. Stockpiling oil-field and pipe-line steel.

2. Plan to stockpile oil products at the start of the war by rationing at once and running the products of rationing into empty tankage, some of which has been provided by government in advance. In addition, industry will contribute to security by erecting the additional tankage which it really needs for its normal operations.

3. Import as much oil as can be accepted without serious prejudice to domestic exploratory activity.

4. Develop synthetics by private enterprise, assisted by basic government research.

5. Develop refinery flexibility to permit higher yields of distilled products.

In the very nature of oil production, long-term future supplies are unpredictable, but any rapid loss of producing capacity is most improbable. Faith that an industry which has so adequately demonstrated its ability to meet demands in the past will continue to do so in the future should be accompanied by continuing close liaison with government in its defense planning. If this be done, the present conclusion that government projects need not extend beyond basic research, detailed planning for emergency stockpiles and production increases, and modest prewar provisions for stockpiling steel and war specialties can be intelligently modified when and if necessary in time to assure constant preparedness in liquid fuels.

PRESENTED BEFORE GROUP SESSION ON "FUELS OF THE FUTURE" UNDER THE AUSPICES OF THE DIVISION OF REFINING, 29TH ANNUAL MEETING OF AMERICAN PETROLEUM INSTITUTE, CHICAGO, NOV. 10, 1949

FUELS—THEIR PRESENT and FUTURE UTILIZATION

By W. M. HOLADAY, R. E. ALBRIGHT, T. L. APJOHN and L. R. STEFFENS
Socony-Vacuum Laboratories

A groundwork study is made of our consumption of energy from the three primary fuels—coal, petroleum and natural gas—together with the possibilities for improving their utilization efficiencies in various fields of use. The relative and absolute consumption of oil and gas is increasing steadily, while the use of coal is declining.

Highest utilization efficiencies are obtained in the application of fuels in heating, the weighted average thermal efficiency for all three fuels under average load conditions being 60%. In the transportation field, however, which consumes 32% of the nation's fuel energy, the overall thermal efficiency is only 5%. Transportation requirements appear to be subject to the greatest reduction through improvements in efficiency of utilization.

For the foreseeable future, sufficent petroleum should be available to meet all transportation requirements. Improving the efficiency of gasoline utilization would increase the availability of liquid fuels for transportation.

Direct utilization of coal and gas should be continued until petroleum is scarce and mostly to the point that the free play of economics dictates the synthesis of liquid fuels.

DURING the past year the United States consumed over 29,000 trillion BTU of energy to power its industrial might; to heat its homes, offices and factories; to fabricate and move its manufactured goods; to transport its population by boat, train, plane, bus and automobile; to cook its food; and to light its homes, places of business and its thorofares.

Sources of this energy were coal, petroleum, natural gas, wood and water power, in order of their decreasing importance. In the past year, petroleum (including natural gas) has exceeded coal by a significant amount in providing the country's energy requirements.

Recent papers have evaluated the practicability of a number of methods of supplementing our energy sources by such means as solar radiation, nuclear energy, wind power, etc. These studies were undoubtedly spurred by the gloomy predictions of the forecasters concerning the short life expectancy of our fluid-fuel reserves. Relatively speaking, petroleum and natural gas will be in short supply long before coal but such an eventuality in a normal economy is a long way off and must be measured in decades or centuries rather than years.

This condition, however, does not detract from the desirability of conserving our fuel resources by using them in the most efficient manner. Of the 29,000 trillion BTU consumed as coal, petroleum and natural gas last year, fewer than 10,000 trillion were used effectively to satisfy these energy requirements. Stated in another manner, the overall efficiency of utilization was approximately 33%. The remainder went, so to speak, unharnessed—wasted in stack gases or exhaust gases or radiated to the air.

In Europe fuel shortages have hampered the rehabilitation of the industrial economy. Consequently, energy in its various forms has been given considerable study abroad as regards its most efficient utilization. This subject will also be a principal topic at the forthcoming World Power Conference in London in July, 1950. The importance of studies of this type in the U. S. exists not so much in impending shortages but rather in the balancing of supply and demand of energy in the event of another national emergency. Conservation then becomes a necessity until supply lines have been reestablished and new production has been brought in.

Since the timetable of such events is unknown, a continuous study must be made of how our energy sources are trending—what utilization efficiencies are being obtained in the various fields of fuel use—and what the possibilities for improvements appear to be. For simplicity in making these evaluations, the ensuing discussion is limited to the production and consumption of energy in the U. S. from the three primary fuels —coal, petroleum, and natural gas. Non-fuel uses of these basic resources have been eliminated from consideration.

I—TRENDS IN ENERGY CONSUMPTION

COAL, petroleum, and natural gas constitute the major sources of energy in this country with water power and wood supplying supplementary quantities amounting to about 10% of the total. Fig. 1 charts the annual consumption of energy derived from coal, petroleum, and natural gas over the past 49 years. In this period, the utilization of heat units has increased almost fivefold from 6,000 trillion BTU to 29,000 trillion BTU. The rise directly reflects the industrial growth of the nation over this period and the breaks in the trend delineate the depression periods 1921-22 and 1930-36.

Coal made its maximum contribu-

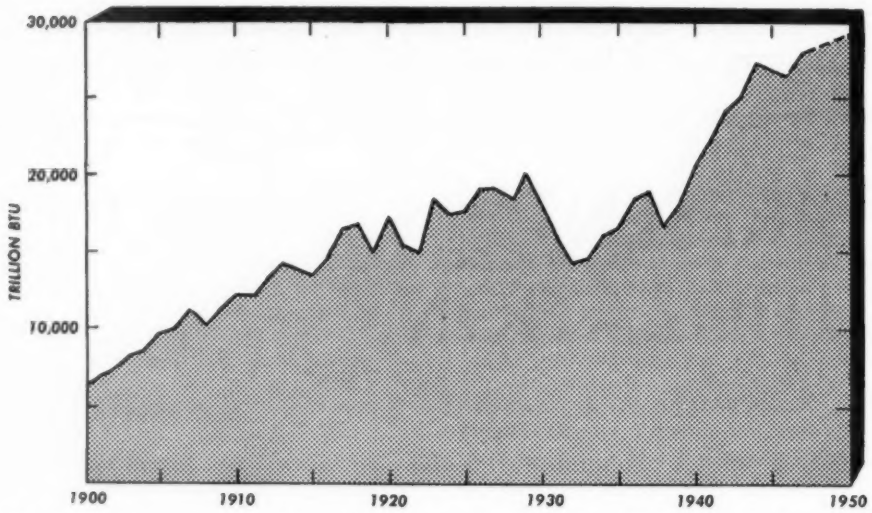


Fig. 1—U. S. consumption of energy, from primary fuels only (coal, petroleum and natural gas; does not include non-fuel uses)

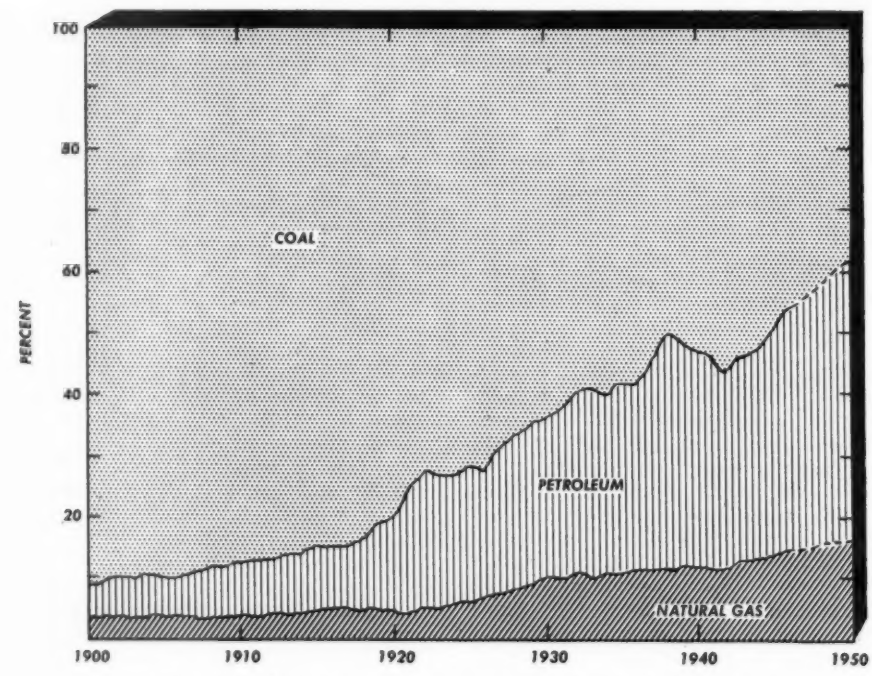


Fig. 2—Relative energy consumption by fuel source

tion during the first world war and, after dipping sharply during the depression years, reached the previous high level during the second world war. Petroleum and natural gas, on the other hand, have shown almost steady upward trends as primary energy sources and today provide more than 50% of the energy generated in this country. There was a large decrease in energy consumption during the early '30s but, as shown in Fig. 2, the percentage of total energy contributed by oil and gas continued to increase even during this depression period. During the early years of World War II, energy requirements increased rapidly and petroleum fuels were diverted to military uses. Coal filled a large part of the resultant civilian and industrial demand because of the relative accessibility of coal reserves as compared to petroleum. However, in recent years, the ascendancy of petroleum and natural gas over coal continues to increase at a rapid rate.

Fig. 3 charts the estimated distribution of energy over the past 10 years among the three main fields: (1) domestic and commercial heating, (2) transportation, and (3) industrial power and heat. A few words of explanation in connection with each of these major fields are in order. Domestic heating comprises both home space heating and cooking requirements; commercial heating includes the heating and cooking requirements of apartments, stores, offices, institutions and public buildings. Transportation is composed of the requirements for automotive, aeronautical, rail and marine motive power with steam, gas, gasoline and diesel engines constituting the principal prime movers in this field.

The field of industrial heat and power is the most complex of the three main categories. Broadly, this includes the energy requirements for all manufacturing and mining operations and, in addition, the production of electrical power for all uses. Consumption of heat and power in petroleum refineries, collieries and in the gas fields is also included in this category as are the requirements for farm usage of fuels to power tractors and similar equipment.

The distribution of fuel usage in 1947 (the latest year for which good figures are available) in terms of per cent of heating value of *total U. S. fuel* consumed is as follows:

	Domestic and Commercial Heating	Transportation	Industrial Power and Heat	Total
Coal	12	11	23	46
Petroleum	7	21	11	39
Natural Gas	4	..	11	15
Total	23	32	45	100

Half of the transportation usage went to cars, trucks and buses; railroads used most of the remainder, with marine operations using only a relatively small amount. As would be expected, the greatest portion of the demand for industrial power and heat is supplied by coal. The major industrial fuel-using industries are the production of electrical power, oil refining, oil and gas production, and the metallurgical industries. These industries consume, respectively, 11, 5, 4, and 4% of the total of all fuels.

A more detailed tabulation of the supply and distribution of the primary fuels for 1947 is given in Fig. 4 and in the Appendix, Tables 4-10. Trend charts are also given in the Appendix (Figs. 9-14) for the individual fuels over the last decade.

If all the data in the foregoing charts are considered in detail, a number of facts become self-evident. First, there is a basic trend with time to the domestic consumption of more and more energy for transportation, heating, and industrial operations. In other words, the U. S. is still growing. Second, while this basic increase of nearly 500 trillion BTU/year exists, actual consumption of energy is tied directly to industrial activity. A major depression can cause a decrease in total energy consumption of nearly 1/3 in a relatively short period of time. Third, both the relative and absolute consumption of fluid fuels (oil and gas) is increasing steadily whereas the use of coal is declining slightly on

an absolute basis and appreciably on a relative basis.

These facts—particularly the last—lead to the consideration of why fuels are used as they are.

1. For automotive equipment (automobiles, trucks, buses, airplanes, construction equipment, etc.) liquid fuels—gasoline and diesel oil—have no practical substitute. The cost of liquid fuels in this country is never expected to increase to the point that the make-shifts (gas producers, compressed gas, or coal-fired steam engines) can compete. Another factor is the requirement for military operations, the basic requisite being portable fuels. At the present time and for some time to come this means liquid fuels.

2. Domestic heating fuels are selected partly on the basis of price and partly on the basis of convenience. The higher income consumers will demand the advantages obtainable now only with fluid fuels—even at a price differential that will force many consumers to get along with coal. A large differential in price between fluid fuels and solid fuels may reduce the number of potential customers and increase the incentive toward eliminating as far as possible the disadvantages inherent in handling a solid which leaves a dusty residue.

3. Fuels for railroad, marine and industrial heat and power are chosen, with few exceptions, on the basis of overall cost.

With this picture, then, of the quantitative consumption of fuels in this country and some of the reasons guiding the trends observed, the next step in the analysis concerns the efficiency of fuels utilization in the several fields.

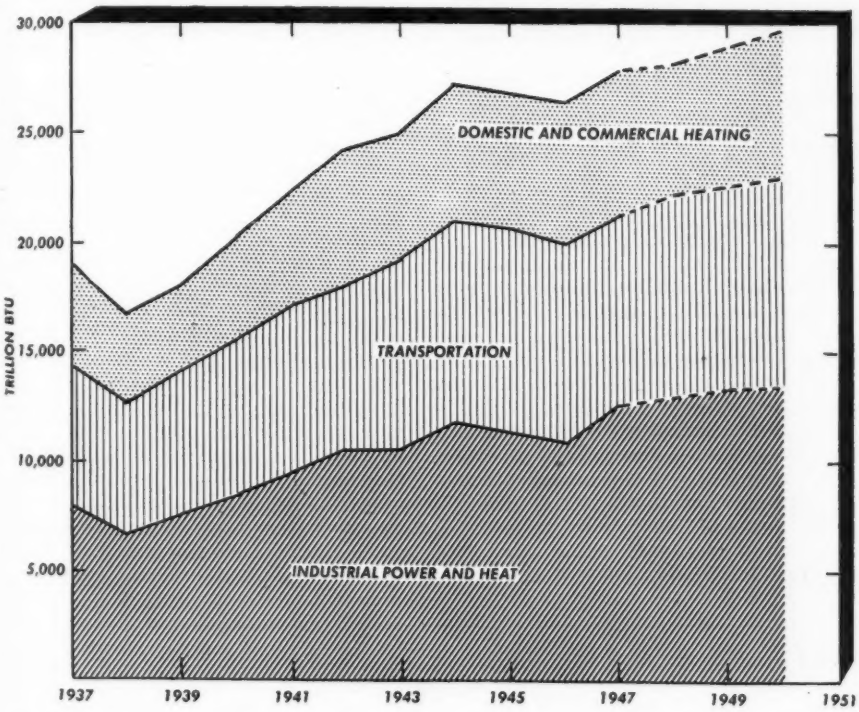


Fig. 3—Energy consumption by field of use (primary fuels; non-fuel use omitted)

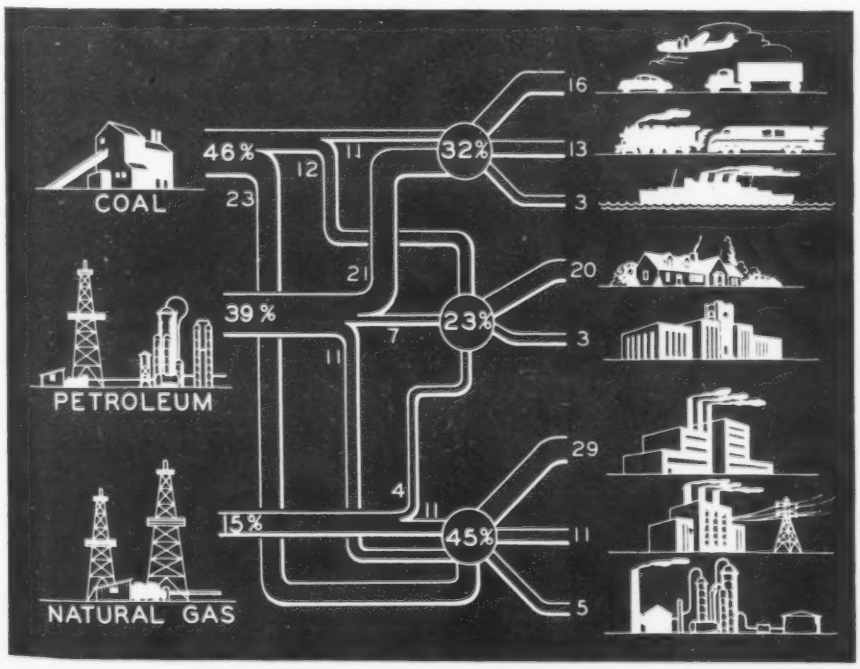


Fig. 4—Primary fuel distribution in 1947, % of total Btu

II—UTILIZATION EFFICIENCIES

As indicated briefly in the preceding section, the efficiency of energy utilization is often disregarded when a selection of fuels for a specific use is made. This frequent disregard of what appears to be a prime factor is based largely on two other factors; namely, availability and convenience of use. However, with demands for energy increasing as they have, consideration must be given to the efficiencies involved in our consumption of national resources.

When comparing the efficiency of utilization of fuels in such varied applications as heating, transportation, and power generation, a common denominator is essential. Thermal efficiency, defined as the ratio of the net usable energy output arising from a fuel in a given application to the total fuel energy input, appears to be a logical basis upon which to compare efficiencies. For space heating and process heating purposes, the net useful energy output has been interpreted to be the difference in the fuel energy input and the usual stack, radiation and ash losses. For transportation, the brake thermal efficiency of a given prime mover multiplied by the transmission efficiency to the air, land, or sea represents a measure of efficiency in this field. For power generation, the usable power output of a plant divided by the total fuel energy input is considered to be a satisfactory criterion of efficiency.

In any application, efficiencies vary widely with load. This has been taken into consideration but, in general, use of average load conditions will be compared with one another. Further, the efficiencies employed are the values for utilization of the fuel after delivery to the equipment wherein the fuel is used. Calculation of these

efficiencies *does not* take into account the energy requirement for transporting the fuel to the point of use, although this requirement is an important factor in fixing the ultimate efficiency of fuel utilization.

As an example, the thermal efficiencies of transporting fuel from producing centers to New York City (neglecting the minor fuel requirements for local gathering and distribution) are shown in Table 1. The transportation of oil by tanker and pipeline shows the highest efficiency —97 to 99+% compared to 88% for coal and 82% for natural gas. With these lower efficiencies, transportation costs of coal and gas may amount to a substantial percentage of the cost of the delivered fuel.

Domestic and Commercial Heating

In the three major fields of Domestic and Commercial Heating, Industrial Heat and Power, and Transportation, the highest utilization efficiencies are obtained in the application of fuels to domestic and commercial heating. As shown in Fig. 5, thermal efficiency in domestic heating increases from 53% for coal to 74% for gas with oil intermediate at 66%. The weighted average for all three fuels under average load conditions is 60%. The low value noted for coal, the principal domestic fuel, is due primarily to the fact that coal is fired by hand which results in over-firing with attendant high losses. Gas, because it is subject to better control than either coal or oil, shows the highest efficiency.

As would be expected, utilization efficiencies are generally higher for commercial heating than they are for domestic heating. Under average load conditions, coal has an efficiency of 60%, oil 71%, and gas 76%. In the case of coal, the higher efficiency in commercial heating is due in part to the use of automatic stoker equipment. In the case of oil, the major factor affecting the higher efficiency is the use of heating plants designed specifically for operation on oil as contrasted to the many conversion units employed in domestic heating.

Industrial Heat and Power

In the field of industrial heat and power, efficiencies under average load conditions range from 33% for coal to 46% for oil as shown in Fig. 6. Gas has a slightly higher utilization efficiency than coal; namely, 39%. The overall weighted average efficiency for fuels utilization in this field is 38%.

The drop from an overall fuels efficiency of 60% in domestic and commercial heating to this figure of 38% is due primarily to two factors. First of these is the low conversion efficiency for the production of electrical energy, and second is the low efficiency in many manufacturing operations where heat is required at very high temperature levels. Manufacturing industries are the largest consumers of industrial fuels and absorb 26% of the nation's available energy. While no great difference in efficiency of fuel utilization among the primary fuels is apparent in specific manufacturing applications, a large variation does exist among the different industries. For example, in the manufacture of brick and fire clay, only 2 to 5% of the total available energy may be utilized effectively, whereas in certain segments of the cement industry as much as 50% may be utilized and still higher values are obtained in operations such as petroleum refining.

It may be noted that the overall efficiency of gas utilization is relatively low (39%). This low efficiency results in part from the consumption of about ¼ of all the gas directly in the gas fields for drilling, process and compression requirements. Utilization efficiencies in this case are about 29% as compared to efficiencies in heating applications of 50 to 80%.

Transportation

While the aforementioned overall utilization efficiencies of 60% and 38% in the respective fields of domestic and commercial heating and industrial heat and power may appear reasonable, the overall efficiency in the transportation field of 5% is quite startling. The individual efficiencies making up this average of 5% at actual load conditions are given in Fig. 7, along with the values for operation at full load. As shown, nearly all the coal used for transportation goes to steam locomotives with a utilization efficiency of 4% at average load. In contrast, liquid petroleum fuels go to cars, trucks, buses, diesel powered ships and trains, steam trains and steam ships with an overall efficiency of 7%. Inasmuch as transportation consumes

TABLE 1—Typical Thermal Efficiencies for Transporting Fuel from Point of Origin to New York City

	Point of Origin	Method of Transport	Thermal Efficiency, %
Coal	West Virginia	Rail (Coal-Steam)	88
	West Virginia	Rail (Diesel)	98
Oil	Gulf Coast	Rail (Oil-Steam)	78
	Gulf Coast	Rail (Diesel)	96
	Gulf Coast	T-2 Tanker	97
	Gulf Coast	Pipeline	99+
Natural Gas	East Texas	Pipeline	82
Synthetic Gas	West Virginia	Pipeline	
	(a) 1000 BTU/cu. ft.		94
	(b) 600 BTU/cu. ft.		90
	(c) 330 BTU/cu. ft.		83

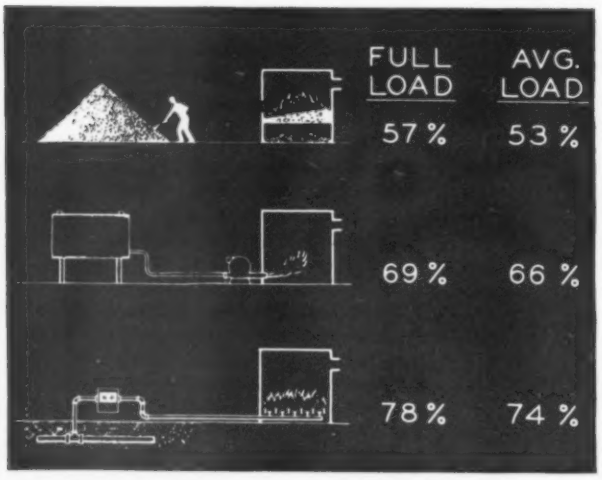


Fig. 5—Domestic heating efficiencies

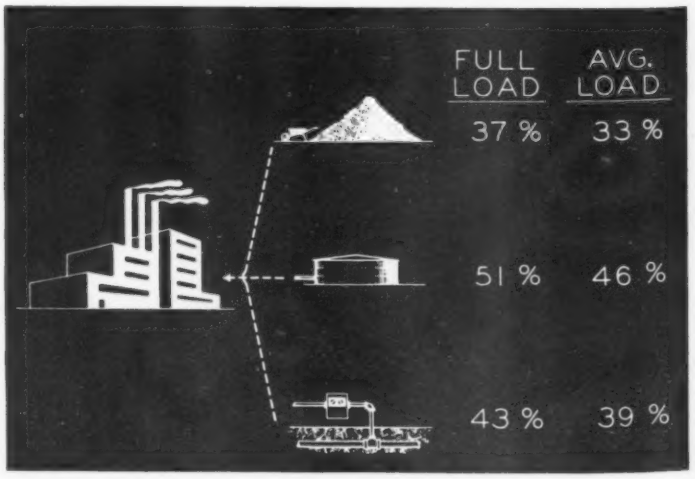


Fig. 6—Industrial power and heating efficiencies

32% of the nation's fuel energy and the major portion of this is derived from petroleum, some detailed consideration of this use is in order.

Automotive and aviation engine requirements consume about 16% of the current energy supply mainly in the form of gasoline. Over 90% of the gasoline is used in the automotive field where the overall actual efficiency of utilization is in the order of 6%. Under full load conditions, an average value of 18% is possible but by far the greatest amount of driving is carried out under part load conditions. The aircraft engine, on the other hand, operates the larger portion of its time closer to full power and therefore at the more efficient level of 18%. At the present state of development, the efficiency of jet propelled aircraft is in the order of 12%.

Railroad operations consume about 13% of the net available energy supply. Coal is the chief fuel in this field of utilization representing about 78% of the requirement. The remainder is satisfied with fuel oil to the extent of 19% and diesel fuel about 3%. These data are for 1947 and, as a result of the rapid replacement of the steam locomotive by the diesel, are already in need of revision. In contrast to the efficiency of 4% with coal fired steam, oil fired steam has a utilization efficiency of 6% while the diesel electric locomotive converts 26% of the available energy into useful work. Because of this high relative efficiency of the diesel, a decrease of 6% in the amount of coal used in railroad operations would be balanced by an increase of only 1% in diesel fuel consumption.

The marine field (including military uses) consumes approximately 3% of the current available energy supply. Fuel oil represents about 83% of the requirement, diesel fuel 12%, and coal only 5%. The diesel is the most efficient propulsion unit designed for shipboard use. Average load efficiencies (including propeller transmission losses) average about 16% for diesel units and about 9% for oil fired steam units. Coal is somewhat lower, generally in the range of 6 to 7%. These efficiencies follow the pattern in railroad use although the level is somewhat higher for steam because of the condensing operations carried out aboard ship. Were it not for the relatively low propeller transmission efficiency, the coal and oil steam values would be still higher and the marine diesel efficiency would approach that of the railroad diesel.

Detailed fuel utilization efficiencies in the field of Domestic and Commercial Heating, Industrial Heat and Power, and Transportation from which the previously mentioned average efficiencies were calculated are given in the Appendix in Tables 7 through 10.

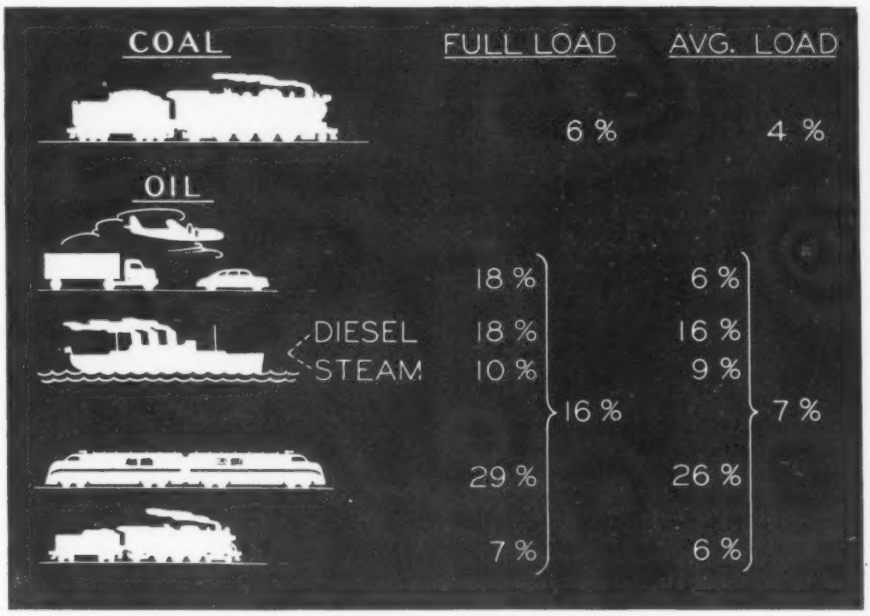


Fig. 7—Transportation efficiencies

The foregoing data show how efficiently—and inefficiently—domestic energy resources are being utilized to meet the nation's demand for heat, power and transportation. Inasmuch as considerable improvement is obviously desirable in many of the conversions discussed—particularly in the field of transportation—the next section is devoted to a consideration of what may be done to improve utilization efficiencies.

III—UTILIZATION DEVELOPMENTS

BARRING another national emergency, no revolutionary changes in the relative amounts of fuels used for specific purposes can be expected for some time to come. Neither will the efficiencies with which fuels are utilized be improved overnight. However, as research activities improve our knowledge of the combustion processes and as consumer desires and availability (or cost) of specific fuels are modified, changes will take place. Considering, then, the next 20 to 30 years ahead, the three main fields of energy consumption should be reviewed for possible improvements in utilization efficiencies.

Domestic, Commercial Heating

Some improvement in the utilization efficiency of fuels in domestic heating can be achieved by way of improved design and proper adjustment. The optimum efficiencies which may be obtained in domestic heating from newly designed stoker fired coal furnaces, combination burner boiler equipment engineered for operation on fuel oil, and from the best designed gas furnaces are compared below with the estimated actual efficiencies currently being obtained.

	—Average Load— Current Actual Efficiency	Optimum Efficiency
Coal	53%	72%
Oil	66%	83%
Gas	74%	79%

The greatest gain can be achieved in coal heating, primarily by the replacement of hand fired units with automatic stoker equipment. The gain to be accomplished in oil heating stems from the replacement of oil conversion units with units specifically designed for operation on fuel oil. In contrast to coal and oil, relatively little improvement is possible with gas units inasmuch as the majority of such units now in operation have been properly engineered for operation on gaseous fuels.

Improvements in house construction may likewise be expected to decrease fuel requirements. Improved design to minimize air leakage, better insulation and radiant heating are some of the means already available to reduce the delivered heat need. Further down the road, solar energy is expected to share some part of the load.

Unlike the industrial field, the price of BTU's in the form of coal for domestic heating must be substantially lower than an equivalent number in the form of oil to force conversions from oil to coal. The cleanliness and convenience factors and ease of control of oil heat in relatively inexpensive equipment apparently carry quite a high monetary value.

The use of natural gas for domestic and industrial heating is a logical method of extending the supply of liquid fuels. In fact, it is so logical that hundreds of millions of dollars

are being spent (with assurance of good markets and profits) to increase gas distribution facilities. At points close to the major gas fields, the price of gas is only a fraction of the price of other fuels. Even at the points served by long pipelines, gas is in many instances cheaper to use than other fuels—an inequality resulting largely from government rate fixing. Thus, gas will supply an increasing volume of heating fuel requirements so that petroleum stocks can be used to supply gasoline and diesel fuel.

Summarizing the foregoing discussion briefly, some reduction in the relative energy demand for domestic and commercial heating will be accomplished through improved heating equipment and home design. A most important factor in this reduction will be the replacement of oil conversion units by modern heating units designed for high efficiency operation on liquid fuel.

Industrial Heat and Power

As stated before, roughly 45% of the nation's energy supply is used in this category—half of this energy comes from coal and the other half is split almost equally between oil and gas. In contrast to domestic heating, utilization efficiencies in this field do not vary greatly among the three primary fuels. Further, economic considerations are of much greater significance to industrial operations than in the field of domestic heating. These factors taken together indicate that improvements in fuel utilization efficiencies depend upon economic forces rather than upon technological developments.

In those industries where efficiencies are extraordinarily low; for example, brick and fire clay, glass, steel, etc., there is usually a demand for high-level heat. After the combustion of the fuel has performed this function, capital investment is required in the way of boilers, condensers, pipelines, heat exchangers, insulation, etc., to recover the low-level heat. There may also be a problem in the useful application of this heat when it is recovered. In such instances, fuel cost establishes the limit to which recovery is profitable. Under today's price structures for the basic fuels, there is little profit incentive to recover low-level heat and, as a result, energy conservation suffers.

Another significant demand in the industrial power category is electric power generation which consumes about 11% of the net available energy supply. Present day electric power generation plants operate at fuel utilization efficiencies of about 20% almost regardless of the type fuel used. A minor exception occurs where the few diesel installations provide electrical power at an efficiency of 29%. Marked improvements in conversion efficiency have been made in the last two decades and, with the domestic consumption of electricity nearly doubling every 10 years, the rapid installation of modern steam plants operating under high pressures and temperatures, and matching the efficiency of diesel operated plants will be effective in raising the overall average.

Hydroelectric installations are not increasing as rapidly as steam generating units. One reason is that the most profitable and practical sites have already been utilized. Further, the large investment involved requires a load factor exceeding 65%. Otherwise, operating and fixed costs for steam plants are lower. Increasing fuel costs will gradually make the marginal hydroelectric capacity possible but the maximum available in this country is estimated to be 50,000,000 kilowatts or 5 times that currently used.

Oil refineries themselves represent another large industrial fuel consumer using about 5% of the country's net available supply. For each 10 barrels of crude oil processed, the average refinery uses one barrel of oil or its equivalent in natural or refinery gas.*

As a result of active conservation programs within most petroleum companies, refinery fuel utilization efficiencies are quite high—in the order of 75%. Consequently, only relatively small reductions in consumption of refinery fuel can be accomplished. Further, as motor gasolines of higher octane number are demanded, the amount of refinery fuel required to process a given volume of crude increases significantly. This factor is considered to be of major importance and is evaluated in the succeeding section on Transportation.

Summarizing the situation in the industrial heat and power field, improvements in utilization efficiency will be forthcoming in certain manufacturing operations if and when fuel costs increase sufficiently to justify capital investments for equipment to recover heat which is available at low energy levels. In many of the manufacturing operations, high efficiencies are being obtained currently and only very limited improvements can be expected.

Transportation

Transportation requirements, amounting to 32% of this country's net energy requirement, appear to be subject to the greatest reduction through improvements in efficiency of utilization. Further, automotive equipment offers the most fertile field since the weighted overall efficiency under normal operating conditions is only 6%.

Increasing compression ratio of current automobile engines is one manner of increasing the efficiency. However, the gains here are quite limited, relatively speaking. A compression ratio increase to 12.5:1 from the current average of 6.7:1 would raise the overall average efficiency from 6% to slightly over 8%. There has already been considerable discussion on the effect of such an increase in compression ratio upon octane number requirement and the economics involved in gearing the petroleum industry to produce substantially higher octane number fuels. No detailed analysis has been published of the energy required to process lower octane number gasoline fractions to the high range that would be required. However, as shown in the following brief tabulation, such processing may well offset a substantial portion of the increased efficiency obtained by increasing compression ratio.

Yields and Plant Costs for 100,000 b/d Refinery

Gasoline Octane No., (research + 1 cc. TEL) ..	85	95
Gasoline Yield, vol.-% of crude	53	44
Refinery Fuel, % of heating value of gasoline produced.	17	27
Refinery Cost, million $	65	91

An alternate to increasing compression ratio is the application of supercharging. Supercharging can be applied in several different ways to effect improvements in economy despite the fact that, heretofore, supercharging has been used almost exclusively to develop higher power rather than better economy.

One means for improving economy which has been discussed in the literature is the use of a smaller engine which would operate unsupercharged most of the time in meeting normal part load requirements but when high power is required would be supercharged. In this fashion the small engine would operate a greater portion of the time at a higher load factor than does the large present-day type of engine. This approach would result in a higher octane number requirement for the small supercharged engine as compared to the larger unsupercharged engine. However, for a given improvement in fuel economy, the increase in anti-knock quality requirement would be less than that accompanying the same improvement in economy via higher compression ratios. This assumes, of course, some provision for cooling of the hot compressed air from the supercharger before it is fed into the engine.

A more recent proposal is based on the use of a small continuously supercharged engine (again with aftercooling) and recovery of the exhaust gas energy in a gas turbine

* Average nation-wide composition of refinery fuel is approximately 30% fuel oil, 30% natural gas and 40% refinery gas. Refinery gas consists of hydrocarbons (C_4 and lighter) produced in cracking operations for the manufacture of gasoline.

geared to the engine. In effect, this approach gives the higher efficiencies obtainable at high compression ratios (or more properly, high expansion ratios) but without the higher octane number requirement associated with increase in compression ratio. Both of these approaches appear sound in theory but present some difficult engineering problems if the cost of installation is not to be prohibitive.

Still greater gains in economy than are obtainable by higher compression ratios or supercharging can be achieved by the development of an automatic transmission which changes the speed ratio between the engine and the rear wheels in order to give the best combination of engine speed and thermal efficiency. In practice, such a transmission would function to give engine operation at or near full load all of the time with the rear wheel output being very nearly a direct function of the engine speed. Adding to the higher efficiency resulting from operation near full load is the decrease in engine friction from the concomitant reduction in engine speeds. With this application, relatively small increases would be encountered in octane number requirement.

One step in this direction can be taken directly; namely, the incorporation of an overdrive mechanism as standard equipment in the new cars being produced. While the improvement in economy which can be achieved in this fashion is only a portion of that to be obtained from the automatic transmission, the proper overdrive will give an improvement comparable to that which can be obtained by going to compression ratios requiring gasolines of 100 octane number and higher.

When and if high anti-knock quality fuels are made available, high compression ratio and the fully automatic transmission or suitable overdrive could be used simultaneously with improved efficiencies from the two sources being additive. Under these circumstances, a really worthwhile doubling of efficiency might result, providing 30 to 40 instead of the usual 15 to 20 miles per gallon.

A most significant factor in the low efficiency of today's passenger cars arises from the motorist's desire for performance and comfort. Cars must be sufficiently powered for high speeds and rapid acceleration to be acceptable to the car operator, although for a majority of the time the engine will be producing power equivalent to less than one-quarter load with accompanying high energy losses. Living room comfort is essential. Vehicle weight contributes almost entirely to this characteristic. Despite the fact that engine efficiencies have been increased about 30% in the past 20 years, today's cars give about the same miles per gallon as did the 1929 models.

There is only one force that can change the attitude of the motoring public on performance and comfort requirements and that is operating cost. Trends in the design of foreign cars (those used at home and not for export) have demonstrated that where fuel costs are high—double or triple U. S. costs—economy of operation has considerable influence. As fuel costs increase, there will be a greater demand for more efficient vehicles at the expense of performance and comfort and there will be a greater incentive for engine and transmission redesign to effect improved economy.

The reciprocating aircraft engine gives little promise for any marked improvement in efficiency. Supercharging provides the high compression pressures which would lead to improved efficiency in the automotive engine. The aircraft unit operates at relatively high load factors almost all of the time. Some improvements may be forthcoming in turbine compounding but these would be relatively minor with reference to

R. E. Albright

L. R. Steffens

T. L. Apjohn

W. M. "Bill" Holaday, senior author of the accompanying paper on the utilization of fuels, has been studying his subject practically since he received a B. S. in mechanical engineering from Ohio State U. in 1925. He joined the Engine Laboratory group of Indiana Standard's Research Department in 1927 "to help make some sense out of our early efforts at knock testing." Later, when the first CFR knock-testing engines were designed and built in 1930, he carried out Indiana's part in their testing, and also participated in the 1932 and 1934 Uniontown, Pa. road tests.

W. M. Holaday

Mr. Holaday became associated with Socony-Vacuum Oil Co. in 1937 as assistant manager of the research laboratories, was granted a leave of absence in January, 1943 to serve with PAW, and was appointed director of the Socony-Vacuum Laboratories when he returned from PAW in September, 1944.

He is chairman of the Fuels and Lubricants Committee of the Research and Development Board of the National Military Establishment; a member of the Power Plants Committee of the National Advisory Committee for Aeronautics, and chairman of the Aircraft Fuels Subcommittee; a member of the Military Petroleum Advisory Board, and chairman of its Aviation Fuels Committee; a member of the Board of Directors of the Coordinating Research Council; and a member of numerous societies, including API and SAE.

Co-outhors with Mr. Holaday are Thomas L. Apjohn, Ralph E. Albright and Lester R. Steffens, all of the research and development department of the Socony Laboratories. Mr. Apjohn is supervisor of the light products division, and has been with the firm since 1936. During the recent war he was on leave, serving in the refining division of PAW. Mr. Albright is assistant supervisor in the light products division, and Mr. Steffens assistant supervisor in the economics section.

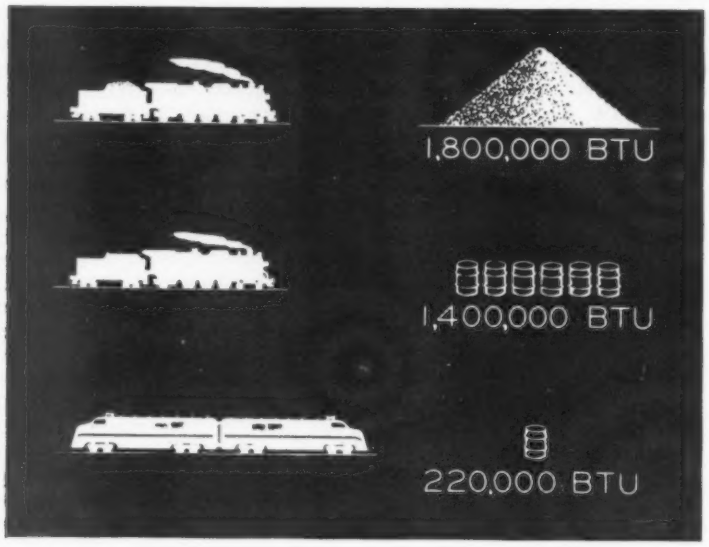


Fig. 8—Energy required per 1000 ton-miles

their effect upon the overall energy supply situation. Turbojet equipment and prop jets are still in the process of evolution and promise to give higher efficiencies. The primary need here is for the development of materials and methods whereby higher temperatures and pressures may be used. Here again, the utilization efficiency may be reduced if the power is used primarily to increase speed.

For railroad applications, oil will continue to replace coal as a result of the superior efficiency of the diesel locomotive. From the fuel conservation standpoint, dieselization should be encouraged. In 1947, the railroads consumed slightly over 300,000 barrels of petroleum per day. Approximately 50,000 barrels of this was diesel fuel. It has been calculated that if *all* of the work done on the American railroads in this year had been accomplished by diesel equipment, the total petroleum product consumption would have been substantially less than the quantity of heavy fuel consumed by the oil burning steam locomotives during the same year. An indication of the relative quantities of diesel fuel, fuel oil and coal to do a given unit of work is given in Fig. 8.

The prophecy has been made that by 1955 there will be at least 30,000,000 horsepower of diesel locomotives at work in this country. This capacity, it is stated, will be capable of handling 75% of the hauling necessary at that time as a result of the greater availability and lower maintenance. If these predictions are correct, overall energy consumption of the railroads will be 63% *less* than would be the case if all coal fired steam locomotives were used for the same job. With such a saving there can be little argument against the use of oil as long as the price does not exceed 6 to 8 times that of coal.

A new development, not yet out from under wraps, is the coal burning turbine locomotive. It has been calculated that efficiencies in the order of 15 to 17%, several times greater than that of the coal burning steam locomotive, can be attained. The practicability of this unit remains to be demonstrated, but should it be proved and if maintenance is not excessive, economics might favor its use over the diesel, particularly in those areas where coal is readily available. A parallel development is underway on gas turbine locomotives using residual oils and a full scale unit has been in operation for some months. Elimination of the energy requirement for pulverizing coal should result in higher overall efficiency for the oil fired turbine.

In the marine field, the diesel, as previously stated, has the highest efficiency—16% as compared to 9% for oil-steam and 6 to 7% for coal-steam. Future improvements in efficiency for the diesel, oil fired steam or coal fired steam appear to be marginal. However, some reduction in overall fuel requirement will be effected by expanded use of diesel ships and high pressure steam turbine units at the expense of less modern steam reciprocating vessels. The only new development in this field appears to be the gas turbine designed for marine use operating on either heavy fuel oil or powdered coal. Efficiencies comparable to those of the diesel appear attainable with either oil or coal as fuel.

Although transportation covers a broad field and currently exhibits the lowest utilization efficiencies, only two phases show promise of significant reductions in fuel consumption. The simpler of these two is the replacement of coal and oil fired steam locomotives by diesel units. The more complex of the two—and the more important—is the improvement of passenger car efficiencies. A major factor influencing the complexity is the real need to improve efficiencies without requiring major increases in anti-knock quality—increases which necessitate consuming more fuel within the refinery to produce the same volume of motor gasoline.

Extension of Liquid Fuels

In the preceding sections the developments which may be expected to give higher utilization efficiencies have been discussed briefly. Of principal interest are the developments affecting the consumption of liquid fuels, the basis for this interest being the fact that liquid fuels cannot be replaced in the transportation field by either coal or gas. Further, taking military considerations into account, an adequate supply of petroleum liquids is an absolute requisite in the event of another war. For these reasons, an estimate has been prepared of the extent to which liquid fuel supplies can be extended by means of improvements in the utilization efficiencies of gasoline, diesel

TABLE 2—Theoretical Extension of Liquid Fuel Supply by Increased Efficiency of Utilization of Liquid Fuels

	% of Total Energy Supply Affected	% Increase in Liquid Fuel Supply	% Increase in Gasoline Supply*
A. Oil for Domestic and Commercial Heating:			
Increased Efficiency (29%)	2.0	5.2	9.2
Improved Maintenance and Insulation (10%)	0.7	1.8	3.2
	2.7	7.0	12.4
B. Oil for Transportation:			
Automotive:			
Increased Efficiency (35%)	5.4	13.9	35.0
Marine:			
Complete Dieselization or Gas Turbine Propusion	1.0	2.6	4.6
Railroad:			
Complete Dieselization	0.3	0.8	1.4
	6.7	17.3	41.0
C. Oil for Industrial Power and Heat:			
Increased Efficiency in Industrial Applications (20%)	1.2	3.0	5.3
Increased Tractor Efficiency (35%)	0.6	1.6	4.1
	1.8	4.6	9.4
TOTAL	11	29	63

* Assuming 70% efficiency for conversion of liquid fuels to gasoline except in the automotive and tractor cases.

fuel and fuel oils. The results of this analysis are presented in Table 2 based on those improvements which may be reasonably expected within the next 10 to 20 years.

This analysis shows that the theoretical extension of liquid fuel supplies in this fashion amounts to 29% with the major contribution being derived from improvements in the field of transportation. Further, if all the savings are compared on a gasoline basis (assuming a conservative efficiency of 70% for the conversion of diesel fuel and fuel oils to gasoline), a worthwhile increase of 63% of the present gasoline supply is indicated.

In a sense, extension of fuel supplies in this fashion constitutes a short-term view. The synthesis of liquid fuels from gas, coal, and oil shale offers another possibility and is discussed in the next section which deals with fuel availability in the more distant future.

IV–FUTURE AVAILABILITY OF FUELS

FOR many years—a number of centuries according to most authorities—there will be plenty of fuel. Despite the occasional pessimistic predictions concerning petroleum availability, reserves are at an all-time high and there are sound, basic reasons for expecting petroleum availability to continue its increase relative to consumption. One of the principal factors in this connection is the development of new techniques for recovering increased quantities of crude oil from established fields and from the fields yet to be discovered. This is not wishful thinking—within the past few years definite advances in this work have been made in the production research laboratories maintained by the petroleum industry.

With regard to coal and shale, the exhaustion of supplies within this country is too remote to warrant speculation in this paper. On a relative basis it is reasonable to assume that petroleum will be the first of our major fuels to be depleted—or to become so expensive to find that competing fuels will be used. Natural gas appears to be the next on the list followed by shale and finally coal. When the period of petroleum plenty starts to draw to a close, the major problem will be to maintain a supply of the liquid fuels irreplaceable for transportation use. An important but secondary problem is to supply fluid fuels for domestic heating as a matter of convenience and for certain industrial applications where precise temperature control is mandatory.

The conversion of natural gas and of coal to synthetic liquid fuels is possible but the practical possibilities of doing it must be subjected to many considerations. Natural gas, at current well-head prices has a considerable economic advantage over the other potential synthetic liquid fuel sources. The technology of the conversion of gas is well developed and construction of the first commercial unit should be finished this year. Conversion of gas would be an easy solution to the future supply of liquid fuels if natural gas availability were unlimited. However, the *practical* potential production of liquid fuel from gas has been estimated at from 150,000 to 350,000 b/d, or about 3 to 7% of the domestic current petroleum production. Much more gas than that required for this rate of production will be available for many years to come but much of it is already committed to other uses.

The conversion of coal to liquid fuels by any of the several versions of the Fischer-Tropsch process is a simple matter—chemically. The coal is reacted with steam and oxygen to give carbon monoxide and hydrogen; these gases are then passed over a catalyst and are converted to liquid hydrocarbons. However, these simple reactions involve a multitude of technical problems, including a number which are not present in the case of conversion of natural gas. Maintenance of catalyst activity; removal of a variety of contaminants from the synthesis gas mixture; temperature control; cooling water requirements; power requirements, particularly for oxygen generation and synthesis gas recycle under high pressure; the recovery or conversion of oxygenated hydrocarbons—alcohols, acids, aldehydes, ketones, etc.—from dilute water solutions: all of these represent engineering development problems of the first order which must be solved if the operation is to be economically attractive.

The remaining potential source of liquid fuels, oil shale, has been utilized on a small scale in various countries for a number of years. The large scale production of shale oil from the mountains of shale located in Colorado was considered by a number of investors and speculators in the 1920's when it was expected that the country would shortly be out of petroleum, and is again receiving extensive study. Shale oil is obtained by retorting the crushed rock at about 1000° F. This operation converts the organic matter to gas, coke, and a reasonable facsimile of a poor grade of crude petroleum. The gas and coke are burned to supply heat for the operation. Since it is necessary to mine, crush, and retort a ton and a half of shale to obtain a barrel of oil, it is apparent that massive and expensive handling and processing equipment will be needed to produce any substantial volumes of shale oil. Raw shale oil can be used as industrial fuel. However, its high sulfur, oxygen, and nitrogen contents make it extremely difficult to refine. In order to obtain good yields of gasoline and distillate fuels of satisfactory quality, it is necessary to resort to intensive refining such as hydrogenation.

Promising techniques in the mining and retorting of oil shale are being studied extensively, much of this work being conducted by the Bureau of Mines at Rifle, Col., and at the University of Colorado. Economic studies have been made on the basis of the present stage in development taking into account such factors as the availability of sufficient water, manpower and the need for product transportation facilities. From these studies it appears unlikely that shale oil will be produced commercially in this country at any time in the near future.

The production of manufactured gas by the conversion of coal and of oil up to the present has played only a small part in the overall fuel picture, since costs have limited the use of such gas to the specialized field of cooking and a minor share of domestic heating. Manufactured gas for domestic use (530 BTU/cu. ft.) is principally "carburetted water gas." Currently, 40% of the manufactured gas is obtained from coal (usually as coke) and 60% from oil.

The conversion of coal to high BTU gas for the eventual replacement of natural gas holds some interesting possibilities. By gasification (to carbon monoxide and hydrogen) followed by catalytic synthesis, high BTU gas could be produced either as methane or as a mixture of propane and butane. In this fashion the energy requirements for transportation of the product would be much lower than for an equivalent supply of energy in the form of conventional 530 BTU/cu.ft. manufactured gas. In any case, the cost of high BTU gas from coal will be higher per BTU than the cost of the coal from which it is produced so that gas could only be attractive in domestic heating requirements where advantage is taken of the convenience value.

The operations discussed above can be divided into two fairly distinct groups. In the first group, the raw material is heated, some decomposition may occur and the products are cooled. Petroleum refining, shale retorting and coking or carbonization of coal fall into this classification. The heat requirements for such operations are relatively low. In the second type of operation, synthesis of liquid fuels from either coal or gas, hydrogenation of coal or of shale

TABLE 3—Thermal Efficiencies of Refining and Conversion Processes

Raw Material	Process	Major Products	Thermal Efficiency of Process*
Petroleum	Refining	Gasoline, Domestic and Industrial Fuel Oil	90%
Petroleum	Refining	Gasoline & Domestic Fuel Oil	88%
Petroleum	Refining	Gasoline	86%**
Petroleum Stocks	Gasification	1000 BTU Gas	65%
Coal	Carbonization	Coke, Gas & Tar***	85%
Coal	Gasification—Current	300 BTU Gas	65%
Coal	Gasification—Potential	300 BTU Gas	75%
Coal	Gasification & Synthesis	1000 BTU Gas	50%
Coal	Gasification & Synthesis	Gasoline	45%
Coal	Hydrogenation	Gasoline	45%
Shale	Retorting	Industrial Fuel	85%
Shale	Retorting & Hydrogenation	Gasoline	60%
Natural Gas	Gasification & Synthesis	Gasoline	45%

* Energy of products divided by energy of fuel input.
** Includes energy in gas & coke produced with gasoline; 70% on basis of gasoline alone.
*** Produced in energy ratio of 13:3:1.

oil, and synthesis of high BTU gas from coal, chemical reactions take place which produce great amounts of heat—the useful portion of which is required within the operation. The thermal efficiency of such operations to produce synthetic fuels is unavoidably low.

Table 3 summarizes the approximate thermal efficiencies of the important fuel processing and conversion operations. As shown by the data in this table, the conversion of either gas or coal to liquid, or of coal to high BTU gas results in a loss of 50% or more of the heating value of the raw material. Aside from all other considerations, the energy losses attending conversion lead to the conclusion that fuels should be used as produced and conversion operations should be limited to the production of those fuels for which there may be no satisfactory substitute.

In the case of natural gas, direct usage is growing at a tremendous rate. Great volumes are being transmitted by pipeline from Texas and the Gulf Coast to points throughout the Middle West and virtually from Coast to Coast with the demands still far from being satisfied. The use of gas as produced is, therefore, a fact, not a recommendation. Because of the seasonal variation in domestic and commercial heating demand, economic considerations will require the use of natural gas for industrial uses as well.

It seems almost elementary that coal as produced will be burned wherever possible and that conversion to synthetic liquid fuels will be used only in the indistinct future when the natural liquid fuel, petroleum, is no longer available in sufficient quantity. However, there are some big practical problems to solve before large scale conversion of coal can become a reality. Substantial expansion of mining facilities will be the first requirement. The manpower to operate the new mines will be a big problem but the investment in the mines will be dwarfed by the investment in the conversion plants. The availability of cooling water is a critical physical limitation—there just isn't enough water available in some areas where coal is located. These pessimistic statements should not be construed to indicate that liquid fuels should not or will not be derived from coal. They are made to emphasize that petroleum resources cannot be supplemented by this procedure for many years to come. In the meantime, new crude oil production and exploration techniques and improvements in fuel utilization efficiencies may well achieve the same objective with, by comparison, a negligible expenditure of capital, steel and manpower.

From all these considerations a pattern of future fuel utilization can be set up in general terms. Petroleum will be relatively plentiful for an unspecified period and its use will continue to increase. When petroleum supplies do become limited, their use as industrial fuel will decline rather rapidly and be replaced in part by gas and in part by coal. Later, petroleum stocks will be diverted from domestic fuel in order to produce the maximum amount of gasoline and diesel fuel. Any shortage of the latter products will probably be made up by conversion of coal. Meanwhile, gas, as long as it is abundant, will take over an increasing part of the industrial fuel load and as long as it is available will be used domestically. Coal, burned as such, may eventually be used almost exclusively for these requirements. The place of shale oil is uncertain but it is likely that it will be used first as industrial fuel to replace petroleum stocks for processing to produce gasoline. Later the shale oil may also be refined to yield gasoline.

V—CONCLUSION

NATURALLY occurring energy sources are adequate to supply the ever increasing demands of this country for centuries to come. Among the three basic fuels—coal, petroleum, and natural gas—the production and utilization of petroleum is of most importance because of transportation demands for fuel in liquid form. For the foreseeable future, sufficient petroleum should be available to meet any and all transportation requirements. A major factor in making this supply of liquid fuel available is the improvement in gasoline utilization efficiencies which can be effected largely through developments in passenger car engines and transmissions. Another factor may well be the development, as a result of economic forces, of smaller, low fuel consumption cars.

Although liquid fuels for transportation can be produced from gas, coal or shale oil, the high energy losses involved in the conversion make such operations unattractive from an energy conservation point of view. Direct utilization of coal and gas as produced is patently more desirable and should be continued until that time in the remote future when petroleum is so scarce or so costly to find that the free play of economic forces dictates the synthesis of liquid fuels. When this situation develops, it is probable that natural gas supplies will also be limited and coal and shale oil will constitute the basic raw materials.

In the event of a national emergency, increased quantities of liquid fuel can be made available for critical uses by the conversion of units now using petroleum to use gas and coal. One paramount consideration in making available increased quantities of liquid fuels for the Armed Forces is a high level of production under normal peacetime conditions. In other words, the greater the production of the industry prior to an emergency, the greater the amount of product that can be supplied to the military when the emergency arises.

The engineering progress that has been made in fuels production and utilization during the last few years has been outstanding. However, efforts on the part of engineers and scientists must be redoubled along these lines and, in particular, on means to improve efficiencies in the field of transportation. In addition, their work must be conducted with a clear concept of the overall energy supply and demand situation if this country is to continue to expand industrially and continue to improve the living standards of its own and the world's peoples.

APPENDIX

Figs. 9-14 . . page 1243
Tables 4-10 . page 1244

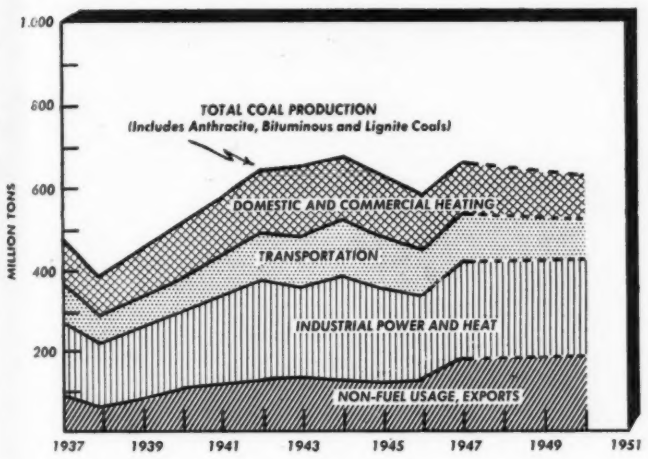


Fig. 9—Estimated coal production and use trends in U. S.

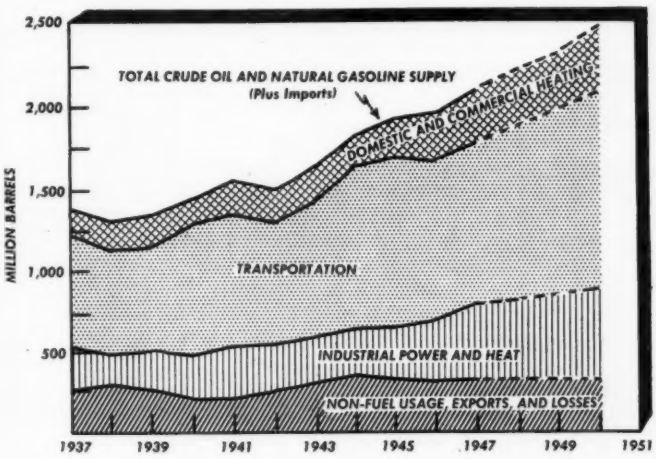


Fig. 10—Estimated petroleum supply and use trends in U. S.

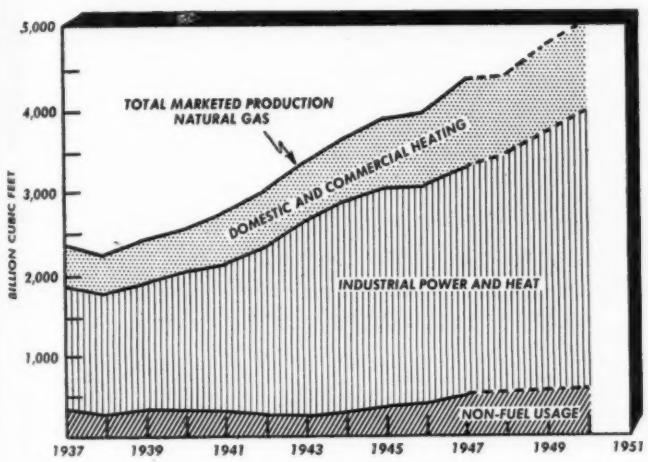


Fig. 11—Estimated natural gas production and use trends in U. S.

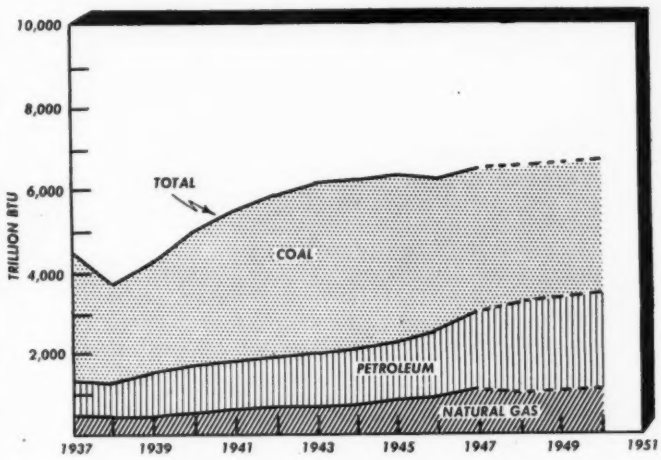


Fig. 12—Estimated domestic and commercial heating fuel trends (primary fuels only)

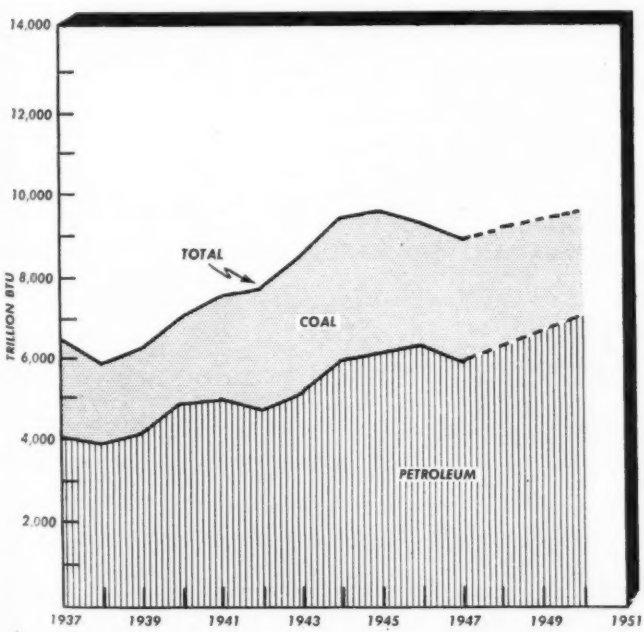


Fig. 13—Estimated transportation fuel trends

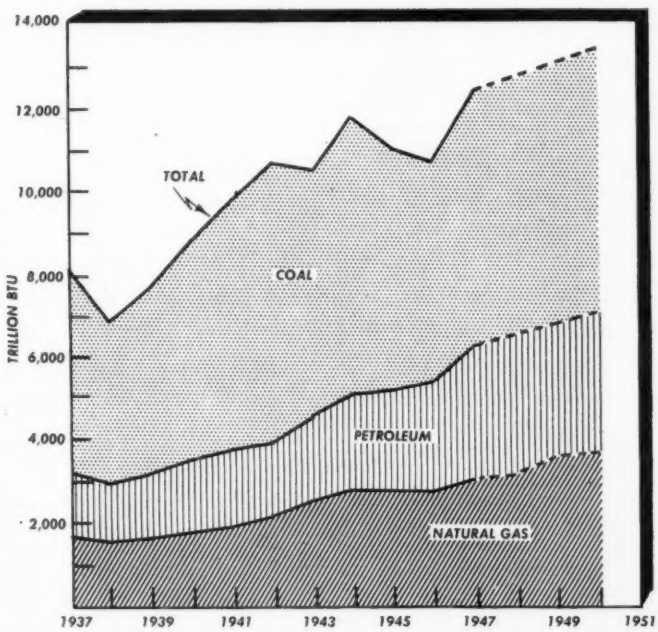


Fig. 14—Estimated industrial heating and power fuel trends (primary fuels only)

TABLE 4—Estimated U. S. Coal Supply and Use—1947

(Includes Bituminous, Lignite and Anthracite Coals)

	Thousand Tons	Weight Per Cent	Wt. Per Cent (Non-Fuel Use Omitted)
A. Domestic and Commercial Heating:			
(1) Domestic	117,269	17.4	23.9
(2) Commercial	14,494	2.2	2.9
B. Transportation:			
(1) Railroads	113,572	16.9	23.2
(2) Vessels	1,689	0.3	0.4
C. Industrial Power and Heat:			
(1) Electric Utilities	89,327	13.5	18.5
(2) Steel Manufacture	10,757	1.6	2.2
(3) Cement Mills	7,893	1.2	1.6
(4) Colliery Fuel	4,489	0.7	1.0
(5) Mfg. Gas and Coal Gas	9,485	1.4	1.9
(6) Food and Kindred Products	14,600	2.2	3.0
(7) Chemical Industry	13,000	1.9	2.6
(8) Paper and Allied Products	13,000	1.9	2.6
(9) Stone, Clay and Glass Industry	9,050	1.3	1.8
(10) Textile Mill Products	7,500	1.1	1.5
(11) Machinery Mfg.	5,510	0.8	1.1
(12) Other Industrial	57,731	8.6	11.8
D. Non-Fuel Usage and Exports:			
(1) Exports	77,116	11.5	...
(2) Coke Production	104,664	15.5	...
Total	671,146	100.0	100.0

TABLE 5—Estimated U. S. Petroleum Supply and Use—1947

(Includes Crude Imports and Natural Gasoline)

	Thousand Barrels	Volume Per Cent	Volume Per Cent (Non-Fuel Use Omitted)
A. Domestic and Commercial Heating:			
(1) Domestic—L.P.G., Kerosine and Distillates	276,573	12.8	15.0
(2) Commercial—Residual Fuels	56,402	2.6	3.0
B. Transportation:			
(1) Automotive and Aviation:			
Gasoline	724,213	33.7	39.5
Diesel	5,500	0.3	0.4
(2) Marine (Includes Armed Services):			
Diesel	17,313	0.8	0.9
Distillates and Residual Fuels	123,385	5.8	6.8
(3) Railroad:			
Diesel	20,476	0.9	1.1
Distillates and Residual Fuels	100,643	4.7	5.5
C. Industrial Power and Heat:			
(1) Oil Refining:			
Still Gas	85,564	4.0	4.7
Distillates and Residual Fuels	64,840	3.0	3.5
(2) Electric Utilities:			
Diesel	7,100	0.3	0.4
Residual Fuels	39,950	1.8	2.1
(3) Manufacturing, Mines and Smelters:			
Diesel	9,972	0.5	0.6
L.P.G., Distillate and Residual Fuels:			
Manufactured Gas	28,130	1.3	1.5
Metallurgical Use	56,895	2.7	3.3
Chemical Ind.	17,500	0.8	0.9
Food and Kindred Products	17,200	0.8	0.9
Textile and Related Products	14,800	0.7	0.8
Machinery Mfg.	10,600	0.5	0.6
Paper and Allied Products	10,200	0.5	0.6
Stone, Clay and Glass Products	8,800	0.4	0.5
Cement	3,630	0.2	0.2
(4) Tractors:			
Gasoline, Kerosine and Distillates	82,921	3.8	4.5
Diesel	9,079	0.4	0.5
(5) Miscellaneous:			
Kerosine and Distillates	37,183	1.7	2.0
Residual Fuels	4,724	0.2	0.2
D. Non-Fuel Usage and Exports:			
(1) Exports	164,463	7.6	..
(2) Lube, Wax, Coke, Solvents, etc.	126,711	5.9	..
(3) Losses	28,666	1.3	..
Total	2,153,433	100.0	100.0

TABLE 6—Estimated U. S. Marketed Production and Use of Natural Gas—1947

	Million Cubic Feet	Volume Per Cent	Vol. Per Cent (Non-Fuel Use Omitted)
A. Domestic and Commercial Heating:			
(1) Domestic	713,000	16.3	18.4
(2) Commercial	277,000	6.3	7.1
B. Industrial Power and Heat:			
(1) Gas Field Usage	985,000	22.4	25.4
(2) Petroleum Refining Fuel	365,000	8.3	9.4
(3) Electric Utilities	334,000	7.6	8.6
(4) Metallurgical	306,000	7.0	7.9
(5) Stone, Clay and Glass Products	210,000	4.8	5.5
(6) Food and Kindred Products	155,000	3.5	4.0
(7) Chemical Industry	115,000	2.6	3.0
(8) Paper and Allied Products	51,300	1.2	1.4
(9) Cement Plants	40,000	0.9	1.0
(10) Other Industrial	325,700	7.3	8.3
C. Non-Fuel Usage:			
(1) Carbon Black Manufacture	523,000	11.9	..
Total	4,400,000	100.0	100.0

TABLE 7—Efficiency of Utilization of Domestic Heating Fuels

(Thermal Efficiency—Percent)

	Full Load Best	Full Load Average	Full Load Weighted Avg.	Actual Load Best	Actual Load Average	Actual Load Weighted Avg.
Gas:						
Designed Unit	84	80	78	79	75	73
Conversion Unit	..	72		..	68	
Oil:						
Designed Unit	88	75	68	83	71	64
Conversion Unit	..	67		..	63	
Anthracite:						
Stoker	80	70	56	74	65	52
Hand Fired	..	58		..	54	
Bituminous Coal:						
Stoker	75	65		70	60	
Hand Fired	..	55		..	51	

TABLE 8—Efficiency of Utilization of Commercial Heating Fuels

(Thermal Efficiency—Percent)

	Full Load Best	Full Load Average	Full Load Weighted Avg.	Actual Load Weighted Avg.
Gas:				
Designed Unit	84	80	78	76
Conversion Unit	..	75		
Oil:				
Designed Unit	88	75	73	71
Conversion Unit	..	70		
Bituminous Coal:				
Stoker	75	65	63	60
Hand Fired	..	60		

TABLE 9—Efficiency of Utilization of Transportation Fuels*

(Thermal Efficiency—Percent)

	Full Load Best	Full Load Average	Full Load Weighted Avg.	Actual Load Weighted Avg.
A. Marine:				
Oil:				
Steam Reciprocating	10	8	10	9
Steam Turbine	12	10		
Diesel (Direct, Geared, Electric)	19	18	..	16
Coal:				
Steam Reciprocating	7	6	..	5
B. Automotive:				
Gasoline	25	18	..	6
Diesel	28	20	..	9
C. Aeronautical:				
Gasoline	22	18	..	18
Jet	..	12	..	..
D. Railroad Locomotives:				
Steam:				
Coal	8	6	..	4
Oil	9	7	..	6
Electric	14	11	..	10
Diesel-Electric	33	29	..	26
Gas Turbine:				
Coal	..	17**	..	..
Oil	..	17	..	..

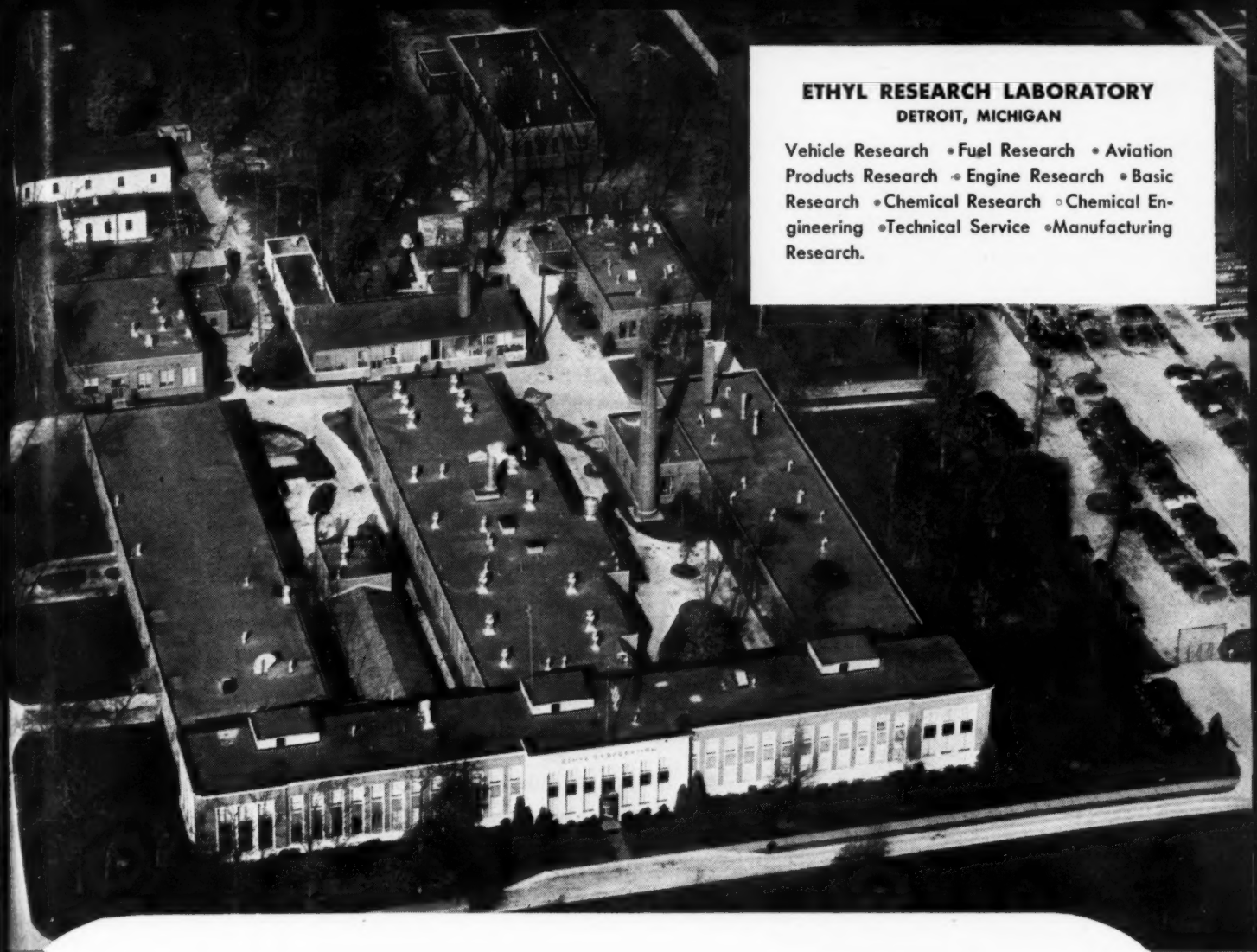
* Marine propeller efficiency of 55%, automobile transmission efficiency of 80%, and airplane propeller efficiency of 80% assumed.
** Estimated—no unit in commercial operation.

TABLE 10—Efficiency of Utilization of Industrial Power Fuels

(Thermal Efficiency—Percent)

	Full Load Best	Full Load Average	Actual Load Average
A. Electric Energy Production:			
Steam (Central Stations):			
Coal	32	22	20
Oil	32	22	20
Gas	31	21	19
Diesel-Generator	37	32	29
Gas Engine-Generator	27	23	21
B. Mechanical Energy Production:			
Steam Reciprocating (All Fuels):*			
Non-Condensing	9	7	6
Condensing	16	13	12
Steam Turbine (All Fuels):*			
Non-Condensing	10	8	7
Condensing	18	15	13
Diesel Engine	36	33	30
Gas Engine	30	26	23
Tractor			
Gasoline	24	18	16
Diesel	24	20	18
Gas Turbine			
Coal	..	20**	..
Oil	..	20	..

* The boiler efficiency of generating steam is approximately the same for the average manufacturing plant using either coal, gas, or oil and is of the order of 80 percent.
** Estimated—No unit in commercial use.



ETHYL RESEARCH LABORATORY
DETROIT, MICHIGAN

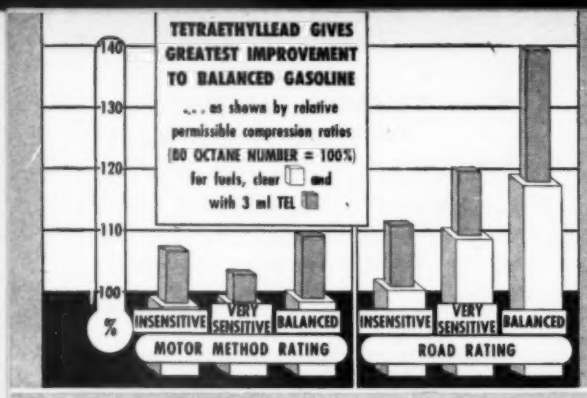
Vehicle Research • Fuel Research • Aviation Products Research • Engine Research • Basic Research • Chemical Research • Chemical Engineering • Technical Service • Manufacturing Research.

One Research Laboratory Working for Many

GASOLINE is produced by many types of companies having varied operations and interests. Some companies manufacture it from crude oil; others recover it from natural gas. For one group it is the major product; for a second group it is less important than other products. One refiner markets on a national scale; another supplies a more limited area. Every one of these companies is important—an essential element in the Oil Industry, which makes gasoline available to the public through thousands of outlets.

Regardless of the nature of a refiner's operations, Ethyl's research and technical service program is designed to assist him in the economical production of gasoline to meet today's and tomorrow's requirements. In the aggregate, this program is intended to serve those interests which all refiners have in common, but in addition it is planned to contribute to the solution of the technical problems of individual refiners.

THE FOLLOWING THREE PAGES SHOW HOW ETHYL RESEARCH SERVES ALL TYPES OF REFINERS



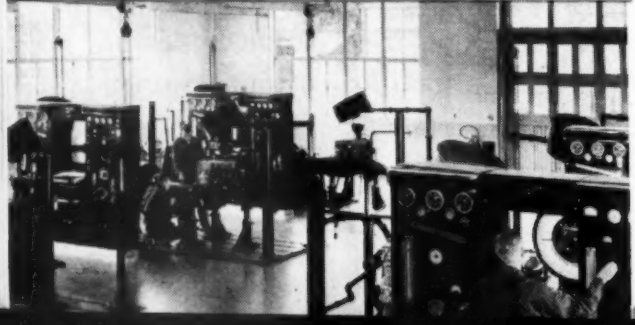
BUILDING BETTER FUELS

APPRAISING NEW FUELS

REFINERY-AUTOMOTIVE LIAISON

SUPPLYING TECHNICAL DATA

EVALUATING NEW ANTIKNOCKS



ETHYL SERVES T

Refiners with Limited Research Facilities are Benefited by these Ethyl Services

1. Indicating Patterns of Fuel Composition

Extensive research on fuel-engine relationships enable Ethyl to indicate general patterns of refinery processing which yield gasolines having good response to tetraethyllead and high antiknock performance in service. Antiknock quality is important but it is not the only requirement of good gasoline. For example, fuels may form combustion products which interfere with normal engine operation. Ethyl passes along to refiners data from its research relating to cleanliness of fuel burning, volatility, sulfur effects, and other properties.

2. Evaluating Experimental Gasolines

As engine design has advanced, the Motor and Research methods of knock rating have become less reliable indices of the antiknock performance of fuels in automobiles. As a consequence, a complete antiknock evaluation of experimental fuels produced by a change in refinery operations must include tests in automobiles or in special laboratory engines.

In appraising experimental fuels Ethyl works closely with engine manufacturers and is able to choose a limited number of vehicles in which knocking is representative of current engines. Ethyl suggests broadly the composition of better gasolines that may be produced economically, and makes evaluations of experimental fuels produced by refiners during studies of proposed changes in their operations.

3. Interpreting the Viewpoints of Refiners

Automotive manufacturers in an earlier period did not find it necessary to be concerned about the specifications of gasoline, and the oil companies had limited interest in the engineering of automobiles. In those days volatility was a more important property of gasoline than antiknock quality.

Today the problems of the two industries are inseparably interwoven. Refiners with large research laboratories have close contacts with engineers of automotive companies. It is equally important that problems and operations of oil companies without extensive laboratories be understood by automotive manufacturers. To many refiners Ethyl's presentation of technical problems represents a real service.

4. Supplying Well-Rounded Technical Information

Ethyl's research program is concerned with the development and manufacture of antiknocks, the refining and use of gasolines, and the design and operation of engines.

Because of this program, and the 26 years of close relations with the oil and automotive industries, Ethyl uniquely serves refiners by providing complete technical service. Thus refiners with limited research facilities are served every day by the 482 employees in Ethyl's Laboratories.

THE REFINER

Refiners with Extensive Research Facilities are Supported by these Ethyl Services

1. Explaining Fuel Performance by Basic Research

Fundamental knowledge of antiknock action is best gained by the study of individual hydrocarbons in special single-cylinder engines and other experimental equipment under closely controlled conditions. This serves as a background for the study of composite fuels in engines. Such research, sponsored by Ethyl in its own laboratories and in universities, contributes to an understanding of more complex fuel-engine relationships and adds to the foundation on which refiners build their fuel research programs.

2. Improving Fuels by Applying Basic Knowledge

When burned in engines, gasoline is affected by a host of variables uniting in different combinations with changes in engine operation. Ethyl's extensive data on the knocking of individual hydrocarbons and composite fuels in single-cylinder engines provides a background for explanation of the knocking pattern of commercial gasolines and indicates fuel properties that will be advantageous in the future.

Ethyl cooperates with oil companies in the application of this knowledge to their individual operations. This involves evaluation of experimental gasolines in specially equipped cars and rating of the gasolines in laboratory engines designed to simulate the operation of automobiles.

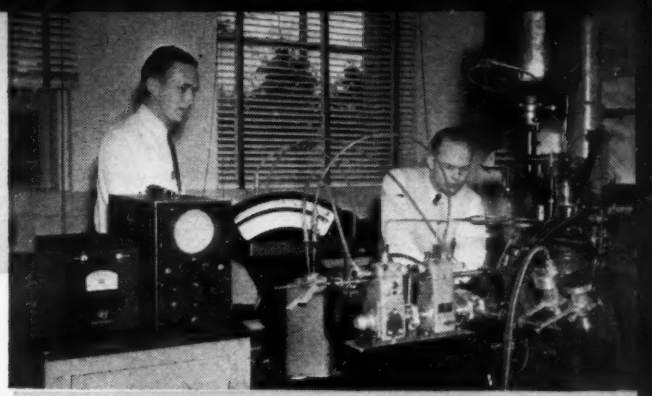
3. Exchanging Information with Oil Companies

Technical liaison is maintained with refiners through frequent discussions by Ethyl personnel with representatives of oil companies at their offices and laboratories. The interrelated problems of fuels, crankcase lubricants, and engines are so numerous and complex that it is advantageous to hold periodic forums in which groups of technical people from an oil company and from Ethyl discuss common problems. These joint technical conferences contribute to broader technical understanding and permit Ethyl to relate its technical activities more closely to the problems of oil companies.

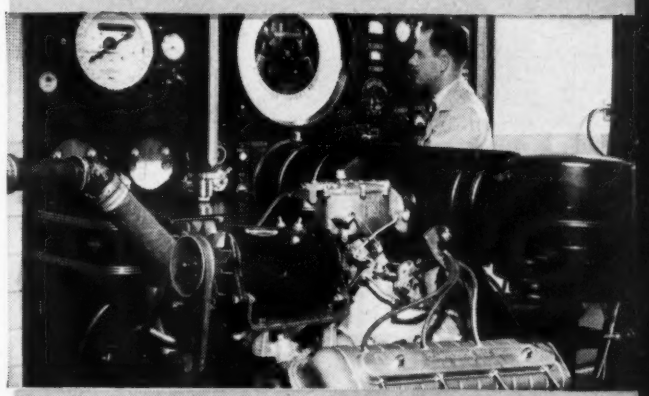
4. Developing Methods and Equipment

Progress in the development of petroleum products requires continuous improvement in experimental equipment and procedures for determination of the complex relationships between gasolines, lubricating oils, and engines. Much of the program of the Ethyl Laboratories is devoted to the development of special equipment and techniques aimed at increasing the significance of laboratory data in respect to the performance of automotive petroleum products in service.

Ethyl is glad to pass along to its customers the details of these developments and the results of its experience in the design and operation of its research laboratories.

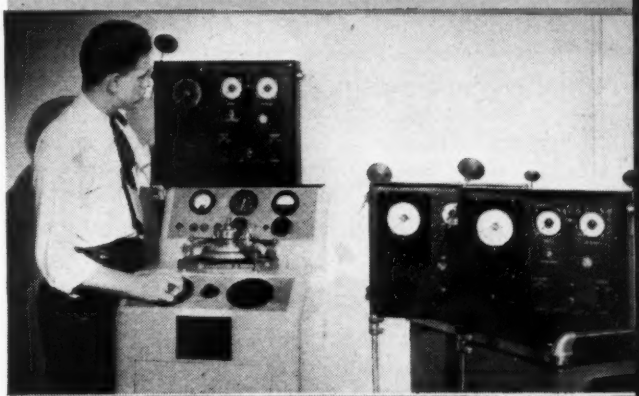


EXPLAINING FUEL PERFORMANCE

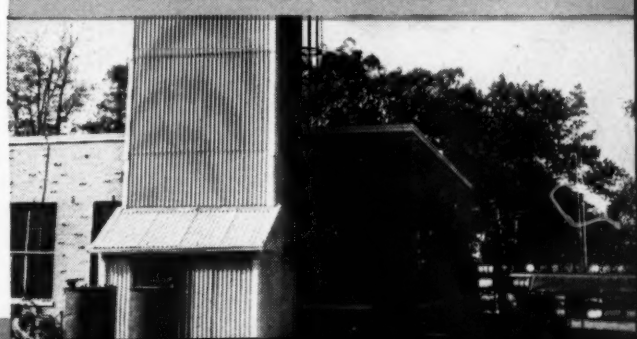


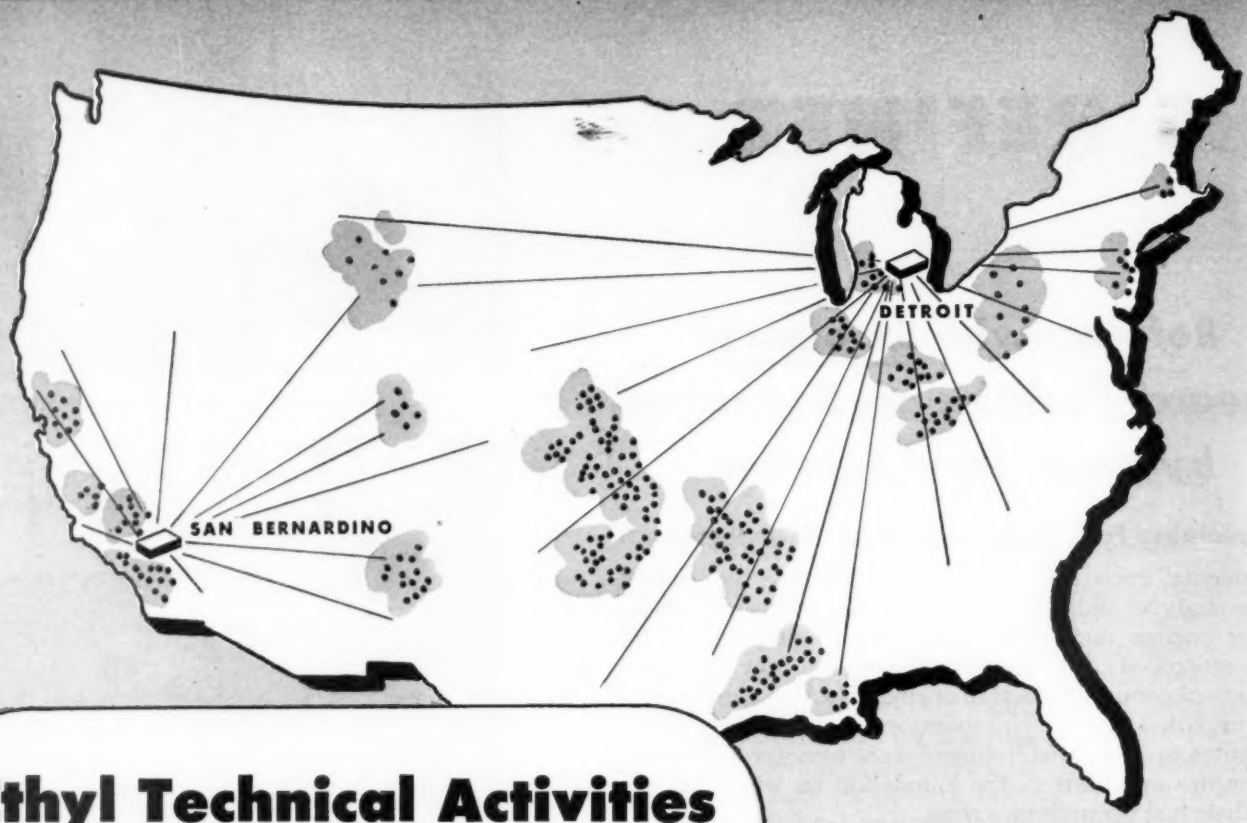
APPLYING BASIC RESEARCH

TECHNICAL CONFERENCE



NEW METHODS AND EQUIPMENT
RESEARCH ON HYDROCARBONS





Ethyl Technical Activities Serve All Refiners

1. Improving "Ethyl" Antiknock Fluids

For more than 26 years Ethyl has conducted continuous and intensive research to improve the quality and reduce the cost of "Ethyl" antiknock compounds. Seven new and better antiknock fluids for motor gasolines have resulted in a substantial reduction in formulation cost which, along with savings in manufacture, has been reflected in lower prices to the oil industry.

2. Preventing Engine-Fuel Problems

After gasoline has been made, it must operate satisfactorily in many types of engines. Working with the manufacturers, the Ethyl Laboratories make every effort to help correct, before production, any features of engine design not likely to be compatible with the products offered by refiners.

3. Creating Mechanical Octane Numbers

Convinced that Ethyl's interests are inseparable from those of its customers, the Laboratories render an indirect but important service to oil companies by developing features of engine design which improve power and economy without requiring higher antiknock quality. Work is done on improvement of combustion chambers, and manufacturers are assisted in the development of intake manifolds which provide faster warm-up and better distribution of fuel to the cylinders.

4. Multiplying the Benefits of Research

The value of information developed by research is not lost through usage, but becomes more valuable as more people employ it. Without Ethyl's broad research program, individual oil companies might find it necessary to carry on many of the expensive research services now conducted by Ethyl.

It is Ethyl's objective to have its research program ensure that the addition of "Ethyl" antiknock fluids to refiners' gasolines will give the maximum improvement in quality, and that the resulting fuel will give the most satisfactory performance in service.

SINCE 1923 — Continuous Research to Provide Better Antiknock Service

ETHYL CORPORATION

RESEARCH LABORATORIES

DETROIT, MICHIGAN . . . 1600 WEST EIGHT MILE ROAD

SAN BERNARDINO, CALIFORNIA . . . 2600 CAJON ROAD

Plant Practices

Practical Tips and Ideas for Improving Operations

Flexible Test Unit Covers Wide Range Of Pressure and Vacuum Instruments

A NEAT instrument test panel, designed by instrument engineer T. L. Clift, and built at the Latonia, Ky., refinery of Sohio Petroleum Co., has proved to have a wide range of flexibility for checking many types of instruments used regularly at the plant. It provides means of testing both pressure and vacuum instruments.

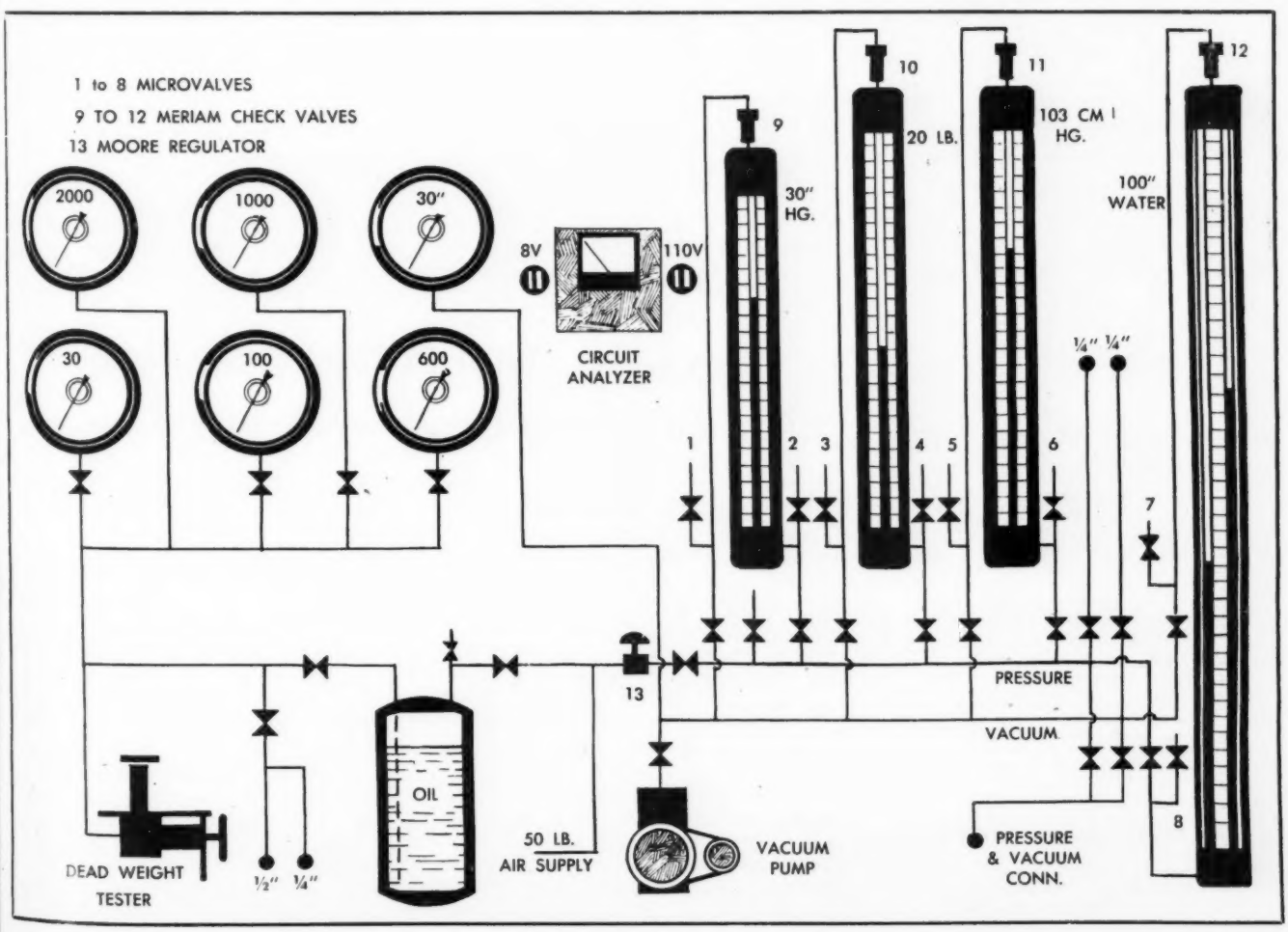
The arrangement of test gages, valves, and piping is shown schematically in Fig 1: the panel proper is illustrated in the photograph. The left side of the panel, as shown in Fig. 1, comprises a set of five test dial-type gages, ranging from 0-30 in. Hg. to 0-2000 psi., a dead weight tester, and two pipe connections—¼ and ½-in.—for hooking up the gages to be tested. Because of the wide range of the standard gages, two size pistons are used interchangeably in the dead weight tester—one for 5 lbs. and the other for 25 lbs.

On the right half, the panel contains three mercury manometers: one 0-30 in., the second 0-20 lbs, and the third, 0-103 cm. Mounted at the end and not in the panel itself (because of its size) is a 0-100 in. water manometer. All manometers are manifolded on the pressure side to the 50 psi. air supply line through a Moore reducing regulator, and on the vacuum side to a small vacuum pump and a 0-30-in. Hg. vacuum gage, dial-type (mounted on the left side of the panel). Instrument connections are provided through two ¼-in. couplings, one on the pressure and the other on the vacuum side of the system, and a third ¼-in. connection hooked to both pressure and vacuum.

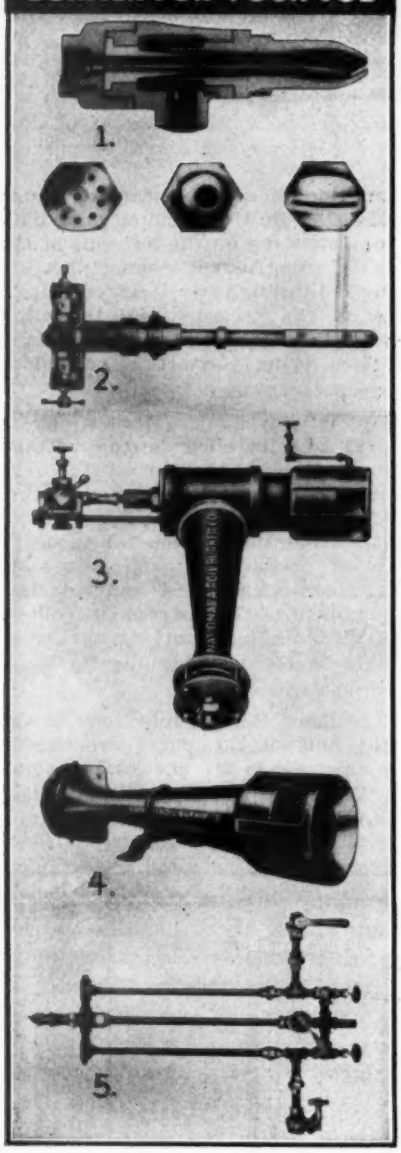
Fig. 1—Piping, valve, and meter layout for Sohio Petroleum Co.'s instrument test panel

Specially-designed Meriam check valves are installed in the vacuum line at the top of each of the four manometers to prevent overshooting and the resultant possible loss of liquid from the manometer tubes. A pair of needle type microvalves—to vent each manometer—provide final adjustment of the instruments following initial adjustment: for example, by the Moore regulator on the pressure system.

The three ¼-in. connections on the right half of the panel are useful, for example, in the checking of flowmeters. The low pressure side of a flowmeter is hooked into the vacuum



THE *RIGHT* OIL BURNER OR GAS BURNER *FOR YOUR JOB*



TYPE "S-A"

1. (For use where steam is available) *atomizes thoroughly* and *burns completely*, the lowest and cheapest grades of fuel oil and tar, requiring only low oil pressure and temperatures.

TYPE "S-A-L"

2. (Large capacity burner similar to TYPE "S-A-R") is adaptable in combination with powdered coal burners in large boilers.

COMBINATION GAS AND OIL BURNER

3. —the "AIROCOOL" Gas Burner in combination with a TYPE "S-A-R" Oil Burner.

"AIROCOOL" GAS BURNER

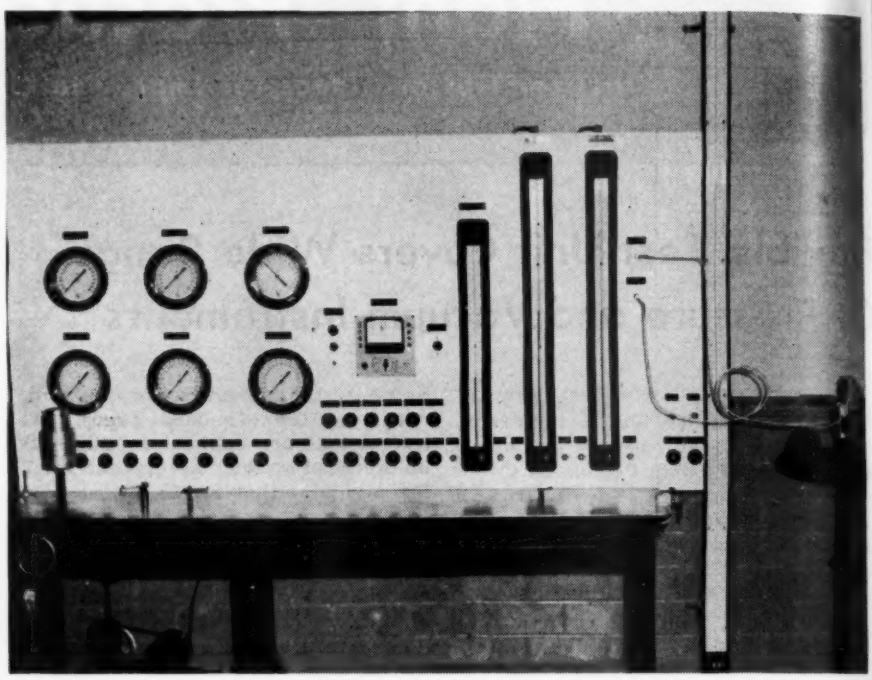
4. (Of venturi type) assures low turndown without burnback.

TYPE "S-A-D"

5. (Refuse Oil Burner) burns acids or caustic oils, sludges, asphalts, tank bottoms, polymer oils, heavy petrolatum, organic oil residuums, waste cutting oils, sulphite pulp liquors, etc.

NATIONAL AIROIL BURNER CO., INC.

Main Offices & Factory:
1297 E. SEDGLEY AVENUE, PHILADELPHIA 34, PA.
Texas Office: 2512 South Boulevard, Houston 6



Photograph shows completed instrument test panel as installed in Sohio Petroleum's shop at Latonia refinery

system and checked with the 0-100-in. water manometer. Simultaneously the transmitted air output of the flow transmitter is hooked through the pressure system to the 0-20 lb. Hg. mercury manometer.

Also incorporated in the test panel is a small circuit analyzer for testing electrical tools: for example, soldering irons on the 8 volt plug and power tools, drills, and the like on the 110 volt plug. The analyzer is a Triplett Model 2405, calibrated in volts, ohms, and amperes.

Construction of the test panel is all-metal, welded. The panel is mounted on an all-welded, metal bench. It measures 8½ ft. long by 54 in. high. The bench is 8½ ft. long by 32 in. high by 28 in. deep, and has a 12-ga. stainless steel top and a drawer at one end for storing supplies.

The bench legs are 3 x 3/16-in. angle iron. Top frame is 2½ x 3/16-in. angle iron. An 8-in. skirt of 12-ga. iron is welded around the bench just under the top. The frame of the panel itself consists of 1½ x 3/16-in. angle iron, braced with 1 x 3/16-in. angle. The panel is of 11-ga. iron and the entire unit is bolted to the bench with ⅜-in. bolts.

"Bazooka" Tool Proves Useful Aid For Repairing Leaks in Catalyst Line

WHEN you made a gadget from a piece of pipe and had no particular name for it—especially during the recent war—you generally wound up calling it a "bazooka". At least that's what maintenance men at Esso Standard Oil Co.'s Bayway refinery decided when they came up with an idea for making temporary repairs on small leaks in the spent catalyst lines of the Fluid "Cat" unit.

The spent catalyst lines, particularly at the point where regeneration air is injected, are susceptible to local erosion. Every once in a while a weak spot breaks open and the fine stream of catalyst shoots out into the air. This is not exactly conducive to an easy repair job, especially since it's not desirable to shut down the entire unit for one small emergency patch.

Esso's bazooka is simply a length of pipe with a gate valve near one end and an air ejector near the other. It is cut at that end so that it will fit snugly against the surface of the spent cat line where the leak has occurred. In use, two men are needed. One opens the gate valve and then holds the bazooka against the spent cat line over the hole and turns on high pressure air to the ejector. In that way the stream of catalyst is guided away from the work area. Then the other man welds the bazooka to the spent cat line, the valve is closed and the long end of

Control Underground Corrosion at Lower Cost

THIS NEW ALCOA BOOKLET TELLS:

- *Where and why corrosion occurs*
- *How buried Anodes control corrosion*
- *Types of Alcoa Anodes*
- *How to install Anodes*
- *Where to get Alcoa Anodes*

Magnesium
ANODES BY ALCOA

ALCOA ALUMINUM

HERE'S THE TECHNICAL STORY ON
Underground Corrosion
By far the most prevalent type of corrosion on buried metal is electrochemical.
At hundreds of spots over the buried metal small differences of electrical potential form local anodes and cathodes, or tiny batteries. Several conditions can cause these batteries to be developed: Variations in the composition of the earth around the metal, breaks in the mill scale on the metal, different concentrations of dissolved oxygen around the metal, "holidays" in coatings and many others.
If all the anodes are eliminated by maintaining the entire surface of the structure to be protected as a cathode, there will be no electrochemical corrosion on that structure. This can be done by applying current to the structure from an external source.
Cathodic protection is simply a technique of impressing, from a direct electrical source such as a galvanic anode, a direct electrical current through the soil or water to the surface of a buried metal structure.

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Please send me a copy of "Magnesium Anodes by Alcoa" on the control of underground corrosion.

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Magnesium
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ALCOA ALUMINUM

New EXPANSION JOINT MANUAL..

IS NOW OFF THE PRESS AND READY FOR MAILING

The book describes in detail the application of Bellows and Packless Expansion Joints to piping installations and processing equipment. Dimensional drawings, tables, formulae and related piping data are also included.

The catalog section describes seven series of expansion joints. The method of adapting special bellows, fittings and combinations of components to various special applications are also described and illustrated in this new publication.

This manual should be helpful and instructive to engineers, architects, piping contractors and purchasing agents.

Write for free Manual and Catalog #50.

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the bazooka is cut off. At turnaround time, the bazooka is taken off and a permanent repair made. Esso has repaired 64 leaks during a four-year period with the gadget.

Back-saving Drum Tilter Also for Wooden Barrels

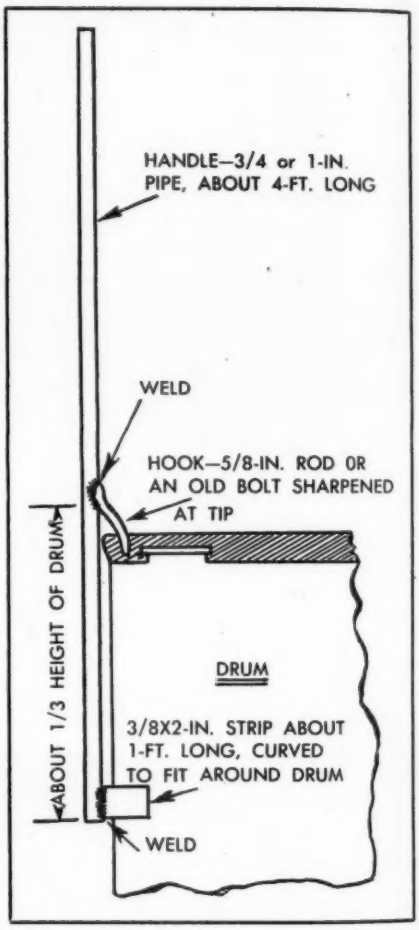
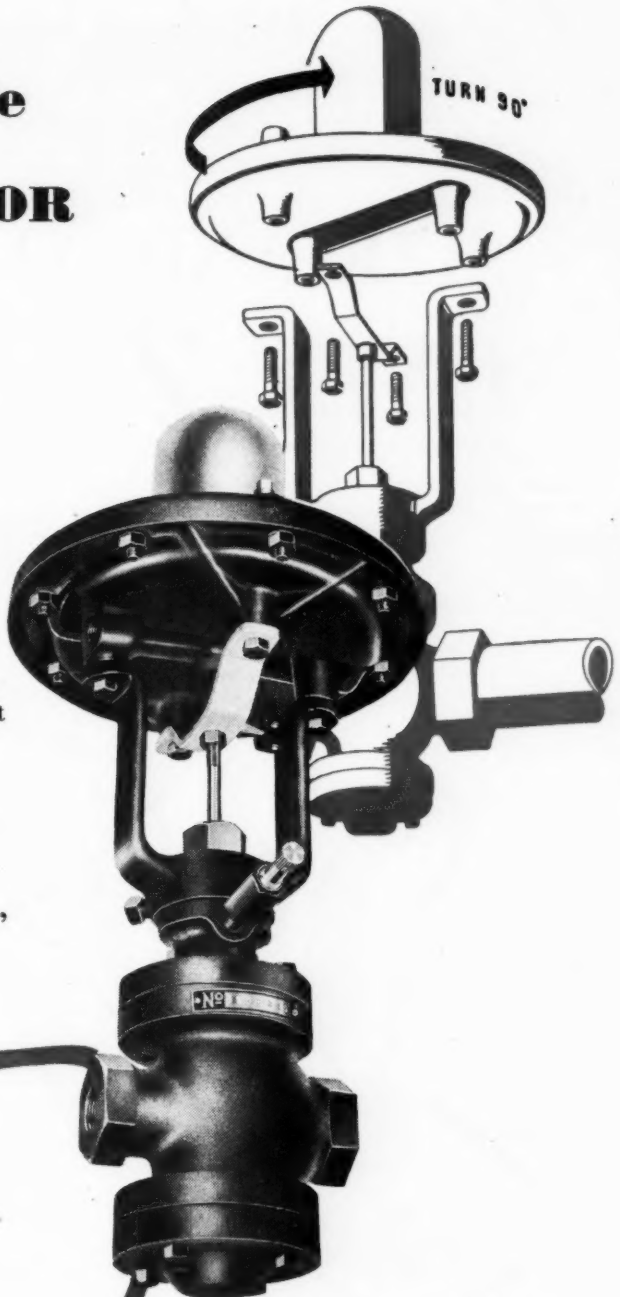

HANDLE—3/4 or 1-IN. PIPE, ABOUT 4-FT. LONG
WELD
HOOK—5/8-IN. ROD OR AN OLD BOLT SHARPENED AT TIP
ABOUT 1/3 HEIGHT OF DRUM
DRUM
3/8X2-IN. STRIP ABOUT 1-FT. LONG, CURVED TO FIT AROUND DRUM
WELD

Fig. 2 — Handy drum-tilter used by California Refining Co.

SCRAP metal and old pieces of pipe can be used to assemble a simple, sturdy tool which will enable one man to handle heavy oil drums and similar packages with no danger of backstrains or other injuries. One-man drum tilters like this have been made and are in constant use now at the Perth Amboy, New Jersey, refinery of California Refining Co.

Construction details are shown in the sketch in Fig. 2. The tool will serve to lift a drum from a horizontal position on the floor to an up-ended position, or it can also be used to lower one from the vertical. California Refining employes have found it a great help for handling the large numbers of 550 lb. (gross) wooden barrels of asphalt which pass in to that particular plant.

NEW! Quick-Reversible STABILFLO VALVE MOTOR makes a 2-in-1 control valve



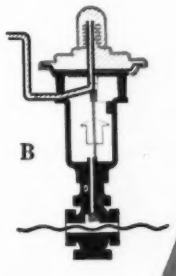
By a simple, ingenious application of relative-motion principles, Foxboro has developed a new valve motor to provide foolproof, almost instant reversibility of valve action. With it, valve action can be changed in four simple steps . . . unbolting diaphragm motor, rotating motor 90 degrees, rebolting motor and shifting air connections. That's all!

This new diaphragm motor brings you *convenience* never before available. It makes it possible to reduce valve *inventories*. And it permits you to standardize, throughout your plant, on the friction-free floating power that has helped make Foxboro Stabilflo Valves the standard of performance in all process industries.

Get all the facts about this new cost-saving development. Write for Bulletin on Quick-Reversible Stabilflo Valve Motor . . . the motor that now makes possible a 2-in-1 control valve. **The Foxboro Company, 246 Neponset Ave., Foxboro, Mass., U. S. A.**

Diagram A shows air-to-close action of a typical Foxboro valve body equipped with the new reversible motor. Yoke is rigidly attached to diaphragm motor housing and valve stem moves integrally with diaphragm plate. Air pressure is always on the same side of diaphragm whether on an air-to-close or air-to-open action.

Diagram B shows air-to-open action. Here motor has been turned 90 degrees. Now mounting lugs of diaphragm motor housing, originally bolted to yoke, are bolted to valve stem strap and lugs on diaphragm plate are bolted to yoke. Although diaphragm plate is rigidly attached to yoke, the diaphragm is free to move.



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NO MECHANICAL SKILL NEEDED. Valve action can be changed without services of a specialist

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Patent Trends in Petroleum Refining

By Peter J. Gaylor, Editor "The Technical Survey"

Continuous Grease Process Yields High Quality Product

IN U. S. 2,478,917, Hain of the U. S. Navy describes a continuous grease making system which produces a high quality product. According to him, high quality greases are critical compositions containing loosely flocculated dispersions of tiny soap crystals in a fluid medium, the size and state of aggregation of the crystals having a pronounced effect on the physical properties of the finished grease. A microcrystalline soap structure of large inter-crystalline surface area is necessary in such a grease to hold the fluid phase in equilibrium and prevent its bleeding out of the mass.

The transition from hot fluid to stable gel must be accomplished as quickly as possible, since slow cooling promotes crystal growth and therefore less interfacial area to hold the fluid. Hence, the temperature should not be any higher than that needed to complete solution of the soap in the base fluid, and the cooling should proceed to equilibrium conditions at such a rate as to avoid formation of coarse soap granules.

Fig. 1 depicts a flowsheet of one system described by him, employing this technique. The fluid grease formulation, or working slurry, is mixed in agitator 10 and pumped by pump 18 at 500-1500 psi through thin heating tube 25 surrounded by insulation 29 in heater 28. This tube is insulated at ends 26 and 27 and is heated by passing a current through the tube through leads 31 and 32 from the secondary of transformer 33. This tube is preferably of stainless steel and has an inside diameter of the order of about twice the thickness of a free-flowing film of the fluid grease base, and a wall thickness of only a few millimeters, just sufficient to hold the pressure developed.

After the composition is rapidly

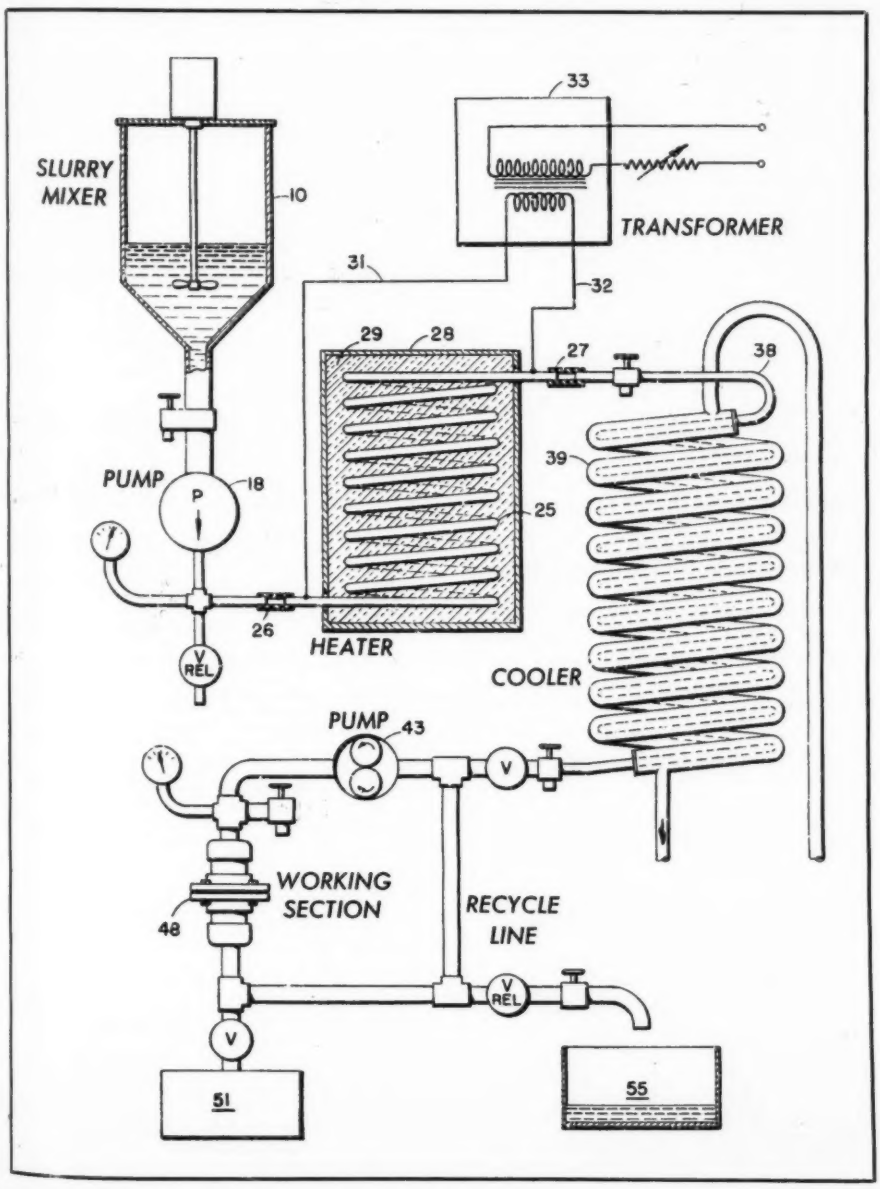
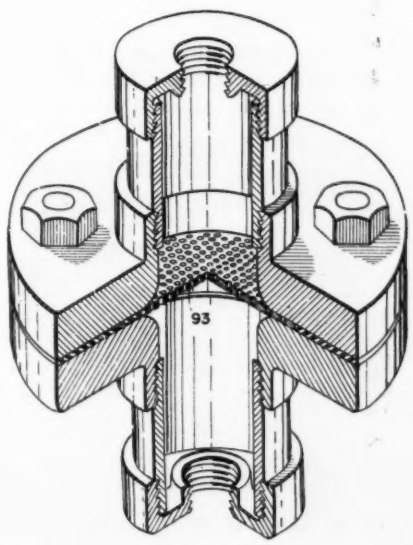


Fig. 1 (left)—Flow diagram of the Hain continuous grease making process, which involves rapid heating and then rapid cooling to avoid formation of coarse soap granules. (U.S. 2,478,917)

Fig. 2 (below)—Sectional view of the working section in the Hain process (item 48 in Fig. 1), showing the perforated plate which breaks up the grease stream



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heated in tube 25, it is cooled rapidly in tube 38 which is surrounded by cooling coil 39 carrying cold water. A variable speed gear pump 43 is connected to the discharge of cooling coil 38, and the cooled grease is pumped into working section 48, the details of which are shown in Fig. 2. A vacuumizing system 51 is provided at the discharge end of the working section, and the grease is recycled back to pump 43 and working section 48, while a stream of finished grease is drawn off into tank 55.

From Fig. 2, it will be seen that the working section consists of a perforated plate 93 which breaks up the grease stream as it passes through the numerous orifices.

Transparent Cutting Oil Uses Sulfurized Abietic Ester

THE production of a transparent cutting oil using a sulfurized ester of an abietic acid is described in a recent patent issued to Standard Oil Development Co.—U. S. 2,480,666. The improvement involves elimination of undesirable precipitation in such oils by the addition of metal sulfonates to the abietic ester during sulfurization.

A typical formula includes the following components:

Flowers of Sulfur	0.90%
Methyl ester of abietic acid	77.30
Sodium sulfonates (70% soaps)	4.52
Light colored, low cold test, coastal mineral oil (40 SSU at 210° F.)	9.09

The ester and sulfonates are heated to 300° F. while stirred and the sulfur added over a period of 5 min. The temperature is then raised rapidly to 350° F. and held until the sulfur is completely reacted. The temperature is lowered finally by quenching with the mineral oil.

Patents Issued in September

The following classified listing gives the patent number, patentee or assignee, and a brief description of all patents believed to be of direct interest to the petroleum processing industries, as contained in the Official Gazette of the U. S. Patent Office for August 30, *Vol.* 625, *No.* 5, *and September* 6, 17, 20 *and* 27, *Vol.* 626, *Nos.* 1-4.

Fuels

2,481,859 (Std. Oil Development Co.)—Diesel fuel containing tertiary butyl perbenzoate.
2,482,102 (Donald E. Dahle)—Antidetonant liquid injection apparatus.
2,482,531 (Wright Aeronautical Corp.)—Antidetonation system employing nitrous oxide.

Conversions

2,480,240 (Sun Oil Co.)—Alkylation of isoparaffins.
2,480,254 (Universal Oil Products Co.) —Phenol alkylation.
2,480,494 (Phillips Petroleum Co.)—Catalytic oil cracking with bauxite-tin oxide.
2,480,670 (Std. Oil Development Co.)—2-zone fluidized destructive distillation.
2,481,245 (Std. Oil Development Co.)—Temperature control for highly exothermic reactions.
2,481,824 (Calif. Research Corp.)—Dehydrogenation of hydrocarbon oil and catalyst pellets.
2,482,056 (Calif. Research Corp.)—Polymerization with solvent-antisolvent system.
Re. 23,151 (Shell Development Co.)—Isomerization of cycloparaffins of nonhydroaromatic structure.
2,482,137-40 (Lummus Co.)—Moving particle catalyst conversion chamber.
2,482,145 (Compagnie Francaise de Raffinage) —Isomerizing n-butane with $AlCl_3$-alkali chloride catalyst.
2,482,877 (Universal Oil Products Co.) —Liquid polymers from ethylene.
2,483,178 (Phillips Petroleum Co.)—Catalyst vessel.

Refining

2,480,242 (Sun Oil Co.)—Purifying naphthene hydrocarbons with active carbon.
2,480,652 (Std. Oil Development Co.)—Extractive distillation of alcohol-hydrocarbon mixtures.
2,481,157 (Universal Oil Products Co.) —Treating halo-hydrocarbons.
2,481,300 (Shell Development Co.)—Removing halogen impurities from hydrocarbons.
2,481,570 (Societe Generale des Huiles de Petrole)—Solutizer refining.
2,481,816 (Std. Oil Development Co.)—Finishing aromatic concentrates.
2,481,843 (Std. Oil Development Co.)—Extraction of aromatics with aluminum halide-aromatic complexes.
2,481,921 (Allied Chemical & Dye Corp.)—Hydrogenating crude naphthalenes.

Chemicals

2,480,266 (Universal Oil Products Co.) —Saturated organic amines.
2,480,267-8 (Universal Oil Products Co.)—Bicycloalkyl aromatic compounds.
2,480,639 (Std. Oil Development Co.)—Carbon disulfide.
2,480,939 (Pan American Refining Corp.)—Xylene-benzene conversion.
2,480,971 (Shell Development Co.)—Sensitization of hydrogen bromide catalyzed oxidation reactions.
2,480,990 (Shell Development Co.)—Cyclopentane carboxaldehydes.
2,481,080 (Shell Development Co.)—Stabilization of unsaturated nitriles.
2,481,140 (Shell Development Co.)—Sulfurization of linear methyl pentadiene polymers.
2,481,158-9 (Universal Oil Products Co.)—Polyhalo-alkanes.
2,481,160 (Universal Oil Products Co.)—Halocycloalkanes.
2,481,211 (Std. Oil Development Co.)—Azeotropic distillation of aqueous isopropanol contaminated by acetone.
2,481,273 (Std. Oil Development Co.)—Isoolefin polymerization catalyzed by Friedel-Crafts salts.
2,481,278 (Shell Development Co.)—Polyoxy alkylene compounds.
2,481,307 (Shell Development Co.)—Stabilization of halogen-containing plastic compositions.
2,481,377 (Shell Development Co.)—Heterocyclic substituted carbinols.
2,481,498 (Phillips Petroleum Co.)—Drying oils by polymerizing olefins (cyclohexene) with HF.
2,481,583 (Sharples Chemicals, Inc.)—Condensation of olefinic compounds with H_2S.
2,482,084 (Socony-Vacuum Oil Co.)—Alkylating thiophene with sulfuric acid catalyst.
2,482,438 (Phillips Petroleum Co.)—Acetylene from ethylene.
2,482,606 (Shell Development Co.)—Polyallyl naphthenate.
2,482,631 (Shell Development Co.)—Ethers of polyalkylated cyclic sulfones.
2,483,049 (Phillips Petroleum Co.)—1,2-Dibromo-3-butene.

Lubricants

2,480,450 (Pure Oil Co.)—Inhibiting oxidation of lubricants.
2,480,564 (Cities Service Oil Co.)—Oil soluble soap of wax acids.
2,480,638 (Std. Oil Development Co.)—Purifying concentrated oil solutions of polyvalent metal sulfonates.
2,480,647 (Std. Oil Development Co.)—Aluminum soap grease.
2,480,660 (Socony-Vacuum Oil Co.)—Lubricant containing oxidation inhibitor.
2,480,664 (Std. Oil Development Co.)—Detergentized lubricant.
2,480,666 (Std. Oil Development Co.)—Transparent metal fabricating lubricant.
2,480,673 (Socony-Vacuum Oil Co.)—Dithiophosphoric acid of alkylated phenol.

Patent Trends

2,480,754 (Gulf Research & Development Co.)—Chromium-containing phenolic amine reaction product.
2,480,823 (The Texas Co.)—Metal derivatives of organic compounds containing a replaceable hydrogen.
2,480,831 (Socony-Vacuum Oil Co.)—Thienyl mercaptans and mercaptols in lubricating compositions.
2,480,832 (Socony-Vacuum Oil Co.)—3-Thienyl ethers in lubricating compositions.
2,480,859 (Rohm & Haas Co.)—Thioether sulfonates.
2,480,873 (Std. Oil Co.—Ohio)—Detergent lubricant.
2,480,940 (Atlantic Refining Co.)—Alkyl tertiary butyl ether.
2,481,257 (Std. Oil Development Co.)—Thickened lube oil.
2,481,268 (Std. Oil Development Co.)—Crankcase conditioning oil.
2,481,372 (Shell Development Co.)—Rust protective lubricants.
2,481,487 (Shell Development Co.)—Phosphorus-sulfide treated ketones for stabilizing lubricants.
2,481,585 (Michael L. Freeman)—E. P. lubricant.
2,482,762 (Shell Development Co.)—Phosphorus-sulfide treated ketone as lubricant stabilizer.
2,483,270 (Union Oil Co. of Calif.)—Sulfonic acid salt reacted with phosphorus as lubricating oil additive.
2,483,282 (Girdler Corp.)—Cooling grease to transition temperature.

Hydrocarbon Synthesis

2,480,341 (Std. Oil Co.—Indiana)—Catalyst for carbon monoxide-hydrogen synthesis.
2,481,089 (M. W. Kellogg Co.)—Synthesis of organic compounds by hydrogenating CO.
2,482,187 (Std. Oil Co.—Indiana)—Hydrogen-carbon monoxide mixtures.
2,482,284 (Std. Oil Development Co.)—Oxygenated compounds and liquid hydrocarbons from hydrogen-carbon monoxide.
2,482,866 (Stanolind Oil & Gas Co.)—Carbon monoxide and hydrogen production.
2,483,132 (The Texas Co.)—Carbon monoxide and hydrogen from hydrocarbon gas.

Specialties

2,480,896 (General Motors Corp.)—Treating Plaster of Paris bonded molds with kerosine prior to autoclaving.
2,481,370 (Shell Development Co.)—Bitumen coated surface.
2,481,523 (Std. Oil Development Co.)—Highly elastic asphalt containing aluminum naphthenate.
2,482,517 (Shell Development Co.)—Corrosion inhibiting composition.

Catalysts

2,480,520 (Pure Oil Co.)—Activated alumina-beryllium oxide catalyst.
2,480,627 (Socony-Vacuum Oil Co.)—Reactivating silica-alumina cracking catalyst.
2,480,669 (Socony-Vacuum Oil Co.)—Extruded gels.
2,480,887 (Houdry Process Corp.)—Catalyst regeneration.
2,481,238 (Std. Oil Development Co.)—Group VIII metal-on-aluminum catalyst.
2,481,253 (Std. Oil Development Co.)—Removing contaminants from cracking catalysts.
2,481,493 (Houdry Process Corp.)—Silica-zirconia gel.
2,481,641 (Ernest C. Bierce)—Non-acid activation process for bleaching clay.
2,481,825 (Std. Oil Development Co.)—Synthetic gels.
2,481,841 (Std. Oil Development Co.)—Catalyst particles having nuclei of previously calcined fines.
2,483,130-1 (Texaco Development Corp.)—Silicon tetrafluoride impregnated alumina catalyst.
2,483,372 (Socony-Vacuum Oil Co.)—Heavy gravity liquid separation of porous catalyst.

Miscellaneous

2,480,672 (Socony-Vacuum Oil Co.)—Porous glass.
2,481,217 & 26 (Std. Oil Development Co.)—2-stage gaseous reduction of iron ore.

How to Obtain Patents

Readers may obtain copies of any U. S. patent from the Patent Office at 25 cents each. Order by patent number direct from the Commissioner of Patents, Washington 25, D. C.

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Uniform Flow Shown Essential In Continuous Coking Unit

In addition to the continuous coking unit described below, this month's review of new and improved devices used in petroleum processing and handling operations on which patents have been issued recently includes:

- **Electronic level gage raises accuracy, safety in readings**
- **Reversible seat ring extends service life of steam valve**

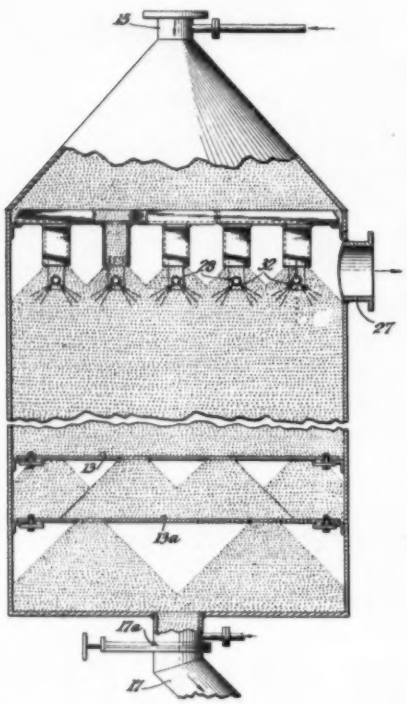

Fig. 1—Reactor for continuous contact coking process (U. S. 2,482,138)

ESSENTIAL TO THE SUCCESSFUL OPERATION of a continuous contact coking unit is the release of the preheated heavy hydrocarbon charge in a uniform flow beneath the surface of a moving bed of the preheated particles upon which the coke is to be deposited.

A cross-sectional view of the reactor for one modification of the process is shown in Fig. 1. Bed particles, which may be any such porous materials as petroleum coke, carborundum, alundum, pumice, crushed firebrick, or cracking catalyst beads, flow continuously by gravity through the reactor. They enter at 15, and leave through conduit 17. Flow is controlled by slotted, horizontal baffles 13 and 13a as well as by slide valve 17a.

Hot hydrocarbon feed—refinery bottoms, residuals, or the like—passes through a manifold header into the horizontal charging conduits 28, whose apertures 32 direct the liquid flow down into the moving bed of particles. The resulting thermal conversion deposits coke on the porous particles and produces a light hydrocarbon gas which disengages and then leaves the reactor via outlet 27.

Excessive cleaning operations such as are met in conventional coking equipment are said to be eliminated. Clogging may occur in the apertures 32, but conduits 28 can be withdrawn easily through the sidewalls of the reactor for any required cleaning.

U. S. 2,482,138, issued Sept. 20, 1949, to August H. Schutte, assignor to The Lummus Co., New York City.

Electronic Level Gage Ups Accuracy, Safety in Readings

ACCURACY AND SAFETY are described as important features of a liquid level instrument employing an electron tube type transmitter. Designed particularly for use with flammable liquids such as gasoline, the device is illustrated in Fig. 2.

As can be seen in the sketch, float movement effects changes in the rotational position of the magnet 6 through the bevel gears 9 and 10. As the magnet revolves, its position relative to the anode assembly 4 of the electron tube 1 is altered. This in turn affects the direction of electron beam 5 emanating from the electron gun cathode 3. This can then be used to control the transmission of electric signals to a conventional receiver.

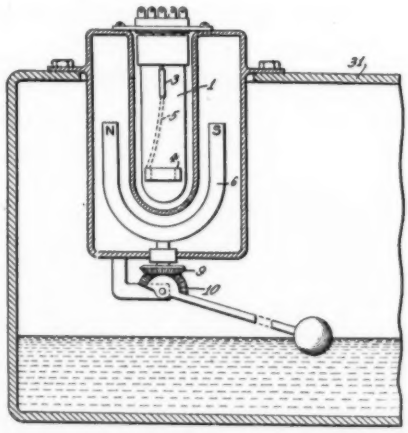

Fig. 2—Electron tube type liquid level transmitter (U. S. 2,483,266)

The electron tube is entirely separate from the liquid tank 31, as is indicated by the method of construction, thereby ensuring safe operation. The accuracy is improved over conventional liquid level transmitters because of the absence of friction; for example, a float-actuated slider riding on a resistance element.

U. S. 2,483,266, issued Sept. 27, 1949, to Clarence A. de Giers and Abraham Edelman, assignors to The Liquidometer Corp., Long Island City, N. Y.

Reversible Seat Ring Extends Service Life of Steam Valve

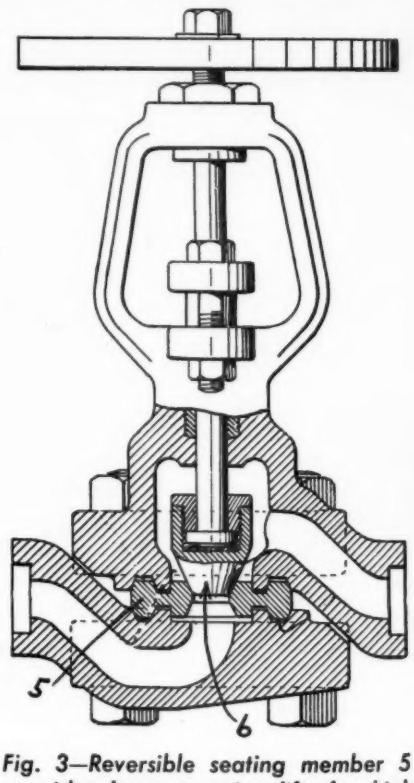

Fig. 3—Reversible seating member 5 provides longer service life for high pressure steam valve (U. S. 2,481,214)

A REVERSIBLE VALVE seat, which can be used in an inverse position after one seating surface has been worn beyond regrinding, is said to be an advantage in a new design for a high pressure steam control valve. It overcomes the problem found in the usual construction where the hard metal seat is made integral with the valve body, and the entire valve must be discarded when the seat has become unserviceable.

The design is shown in Fig. 3, the seat being indicated generally by 5. The valve proper comprises a two-part body with the combination seat and seal member or ring 5 located

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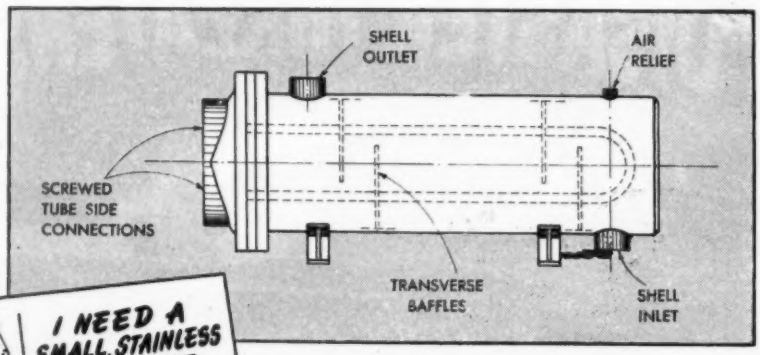

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The exchanger is fabricated in 3 shell sizes and 3 tube lengths to provide a total of 9 selections ranging in size from 8 to 50 sq. ft. Where more surface is required multiple units may be connected in series or parallel.

MATERIALS OF CONSTRUCTION

The shell is of steel, with Type 304 stainless steel tubes (⅝" OD x 18 BWG), tube sheet, and cast channel. Baffle spacing of 3" develops reasonably high shell side velocities.

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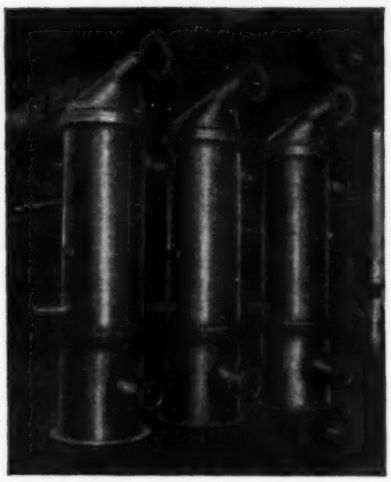
The Whitlock Type R or U-tube construction allows operation with relatively high differential shell and tube side temperatures—permits individual thermal expansion. The U-tube design, suitable for a wide range of service, also makes a unit that is low in cost. This Type 1-R-2 Exchanger may be exactly what you want—write today for additional information.



RECENT GROUP OF CALANDRIAS

These 700 sq. ft. straight tube, fixed tube sheet calandrias were recently built by Whitlock. The liquid to be evaporated circulates through the tubes, with steam in the shell side. Construction is of steel throughout and dimensions are 31" I.D. by 8'8" long overall. Design pressures: shell side 300 p.s.i., tube side 150 p.s.i. The units were furnished complete with fabricated reducing channels and supporting bases as required. Whitlock can design and build special heat transfer equipment to exactly meet *your* needs!

WHITLOCK

DESIGNS and BUILDS Bends • Coils • Condensers • Coolers • Heat Exchangers
Heaters • Piping • Pressure Vessels • Receivers • Reboilers

between the upper and lower portions of the body. When the seating surface in contact with the plug member 6 becomes worn, it is a simple matter to disassemble the body, turn over the ring 5, and thus provide for an extended service life.

U. S. 2,481,214, issued Sept. 6, 1949, to Joseph J. Harper, Lansdowne, Pa.

Other Recent Patents

Electric Motor-operated Valve, designed for positive action against inlet pressures of up to 700 psi., and with automatic locking in either the open or the closed position for any selected period of time. U. S. 2,482,199, issued Sept. 20, 1949, to Edward G. Miller and Ralph E. Engberg, assignors to Alco Valve Co., St. Louis.

Pressure-vacuum Regulator of the manostat type, utilizing the principle of the so-called Cartesian Diver. U. S. 2,482,167, issued Sept. 20, 1949, to Roger Gilmont, assignor to Emil Greiner Co., New York.

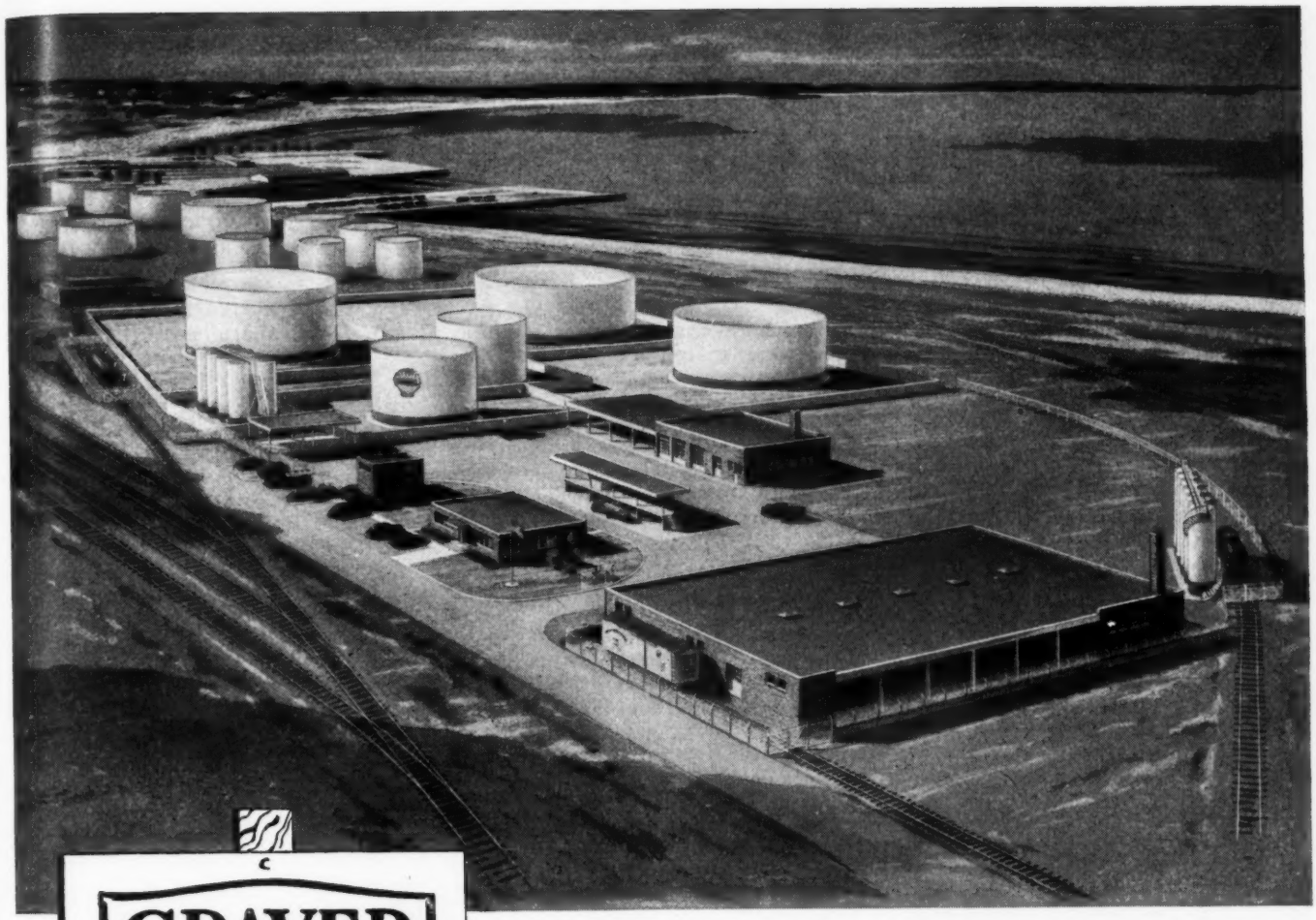
Gate Valve of the "through-conduit" type, for fluids under high pressures, and employing a gate comprising two double-tapered sections which can be centered accurately for both efficient flow and efficient seating. U. S. 2,482,409, issued Sept. 20, 1949, to James M. Fowler, assignor to W-K-M Co., Houston.

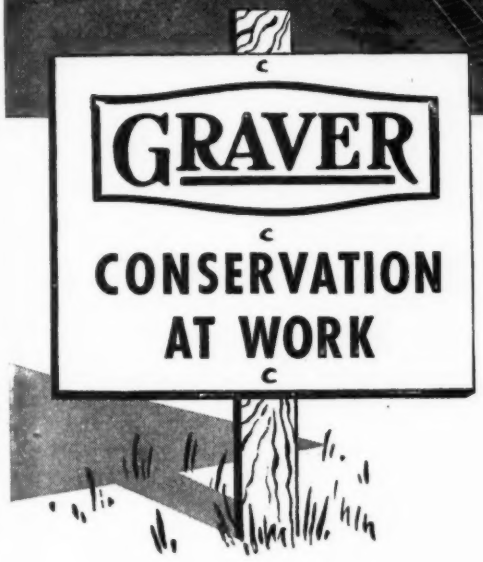
Rotary Air Preheater of the two-pass regenerative type, in which distortion of the rotor due to temperature differences is minimized, and corrosion effects on certain sections of the heat transfer plates due to cooling by the gases is lessened. U. S. 2,480,277, issued Aug. 30, 1949, to William D. Yerrick, assignor to Air Preheater Corp., New York.

Liquid-sealed Lifter Roof storage tank in which considerable saving is effected in the quantity of sealing liquid, and loss of such liquid, due to evaporation and/or absorption, is diminished. U. S. 2,481,184, issued Sept. 6, 1949, to John H. Wiggins, Chicago.

Automatic Ratio-Controller for the flow of fluids in several pipe lines and for effecting changes in a flow-rate which are linearly proportional to the deviations of another independently-variable flow-rate. U. S. 2,481,496, issued Sept. 13, 1949, to Nathaniel Brewer, assignor to Fischer & Porter Co., Hatboro, Penna.

Proportioning Valve designed specifically for use in foam-producing fire extinguishment apparatus. U. S. 2,480,925, issued Sept. 6, 1949, to Charles D. Hirst and George L. Woodington, North Sacramento, Calif.





Graver equipment at the Jones Island (Milwaukee) Terminal includes four cone roof tanks and an Expansion Roof Tank with a total capacity of 10,206,000 gallons.

at SHELL'S MILWAUKEE TERMINAL

• Safe gasoline storage and prevention of vapor losses are insured by the use of a Graver Expansion Roof Tank manifolded with four Graver Cone Roof Tanks at Shell's new marine terminal at Milwaukee.

This is Shell's largest postwar construction in a chain of new or expanded distribution centers and the importance of conservation is pointed up by the size of the operation. About 42,000,000 gallons of regular and premium gasolines, domestic heating oil, and prime white will pass through the terminal every year.

You are urged to inspect the economic advantages of the Graver Expansion Roof — its record of savings of salable products and its *proven* features of safety, positive action, and freedom from maintenance. For complete and convincing case histories, get in touch with Graver at once.

FABRICATED PLATE DIVISION

GRAVER

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA

NEW YORK • PHILADELPHIA • CHICAGO • CATASAUQUA, PA. • HOUSTON • SAND SPRINGS, OKLA.

NEWS OF

Manufacturers—Suppliers—Engineering Firms

Serving the Petroleum Processing Industry

Insulation Solves Dual Problem

Method of hanging thermal insulation on aluminum walls in refinery building

Thermal insulation was found to be the solution to a dual problem in a large, all-metal building constructed recently at the Toledo, Ohio, refinery of Sun Oil Co. The one-story structure, 640 ft. long by 40 ft. wide, has sheet aluminum walls and roof, and presently serves as a craft shop and tool crib.

Because of aluminum's high heat conductivity, insulation was needed both to prevent overheating of the interior during the summer and to permit economical heating by steam unit heaters during the winter months. The material used was Owens-Corning Fiberglas Corp.'s "PF" insulation, two in. thick, unfaced and unpainted, applied to the walls and roof by a low-cost, rapid method. The installation in the entire building was completed by a crew of nine men in less than three weeks.

For applying insulation to the walls, clips were first affixed to the aluminum walls with standard adhesive. The batts of insulation then were impaled on the clips and the prongs bent back flush with the insulation surface. Clips were located on 12-in. centers horizontally. Vertically, three clips were spaced at an equal distance between the girts which are 65 in. apart.

Insulation was applied to the roof by using wooden strips attached to the steel beams, which, in combination with fasteners applied to the top of the insulation, hold it firmly in place.

Republic President Heads ASME

The election of James D. Cunningham, president of Republic Flow Meters Co., of Chicago, as the national president of the American Society of Mechanical Engineers for 1950, has been announced. Mr. Cunningham in 1911 founded and became president of the Steam Appliance Co., now Republic Flow Meters Co. He has previously held office as a manager and regional vice president of the ASME and has served on many committees. He became a Fellow of the society in 1936. He will assume his new office at the end of the 1949 annual meeting of ASME in New York, Nov. 27 to Dec. 2.

Clapp Names New President

Clapp Instrument Co., Webster, Mass., has appointed Arthur S. Brown as president, Charles Clift as treasurer, and T. W. Lanman, vice president. Mr. Brown has been in the instrument field a number of years, having been associated formerly with Manning, Maxwell & Moore, Mason-Neilan Regulator Co., and Fischer & Porter Co. He has been acting as general manager for Clapp for the past several months.

American Cy Promotes Moore

L. P. Moore has been named manager of the new products development department of American Cyanamid Co. With American Cyanamid about 12 years, first in the Stamford research laboratories and later in the executive offices in New York, Dr. Moore most recently served as the company's European technical representative. His new work will be devoted to the supervision of new products development and market research activities.

Replacing him as European technical representative is Dr. E. W. Cook, who joined the company in 1940, and had been assistant chemical director previously.

A.O. Smith Subsidiary Officers

L. B. Smith

Officers and directors have been announced for the new A. O. Smith Corp. of Texas, a subsidiary owned jointly by A. O. Smith of Milwaukee and Sheffield Steel Corp. which will build and operate a new plant in Houston for manufacturing large diameter welded steel pipe.

Officers are A. von Wening, chairman of the board; L. B. Smith, president; Dennis F. McCarthy, vice president; J. M. Floyd, vice president; Morris J. Vollmer, secretary-treasurer; and Robert B. Heinzen, assistant secretary-treasurer.

Patterson Opens Plant in Toronto

Patterson Foundry & Machine Co., East Liverpool, Ohio, has announced the opening of a new plant at Toronto for its Canadian subsidiary. With a floor area of 25,000 sq. ft., the new installation is fully equipped to manufacture the company's complete line of industrial processing units and equipment. This includes synthesizing, gas absorption, hydrogenation, thermal reaction, and other types. In addition, a process engineering division will be headquartered at Toronto.

Earl Smith Joins Brown & Root

Earl C. Smith, previously job and design engineer for Lummus Co., has joined the sales engineering staff of Brown & Root, Inc., Houston. Mr. Smith's background of engineering and design in the petroleum processing field includes, in addition to Lummus, The Republic Oil Refining Co., M. W. Kellogg Co., Gulf Oil Corp., Maritime Petroleum Corp., Richfield Oil Corp., Anderson-Prichard Oil Corp., Shell Oil Co., and Ashland Oil and Refining Co.

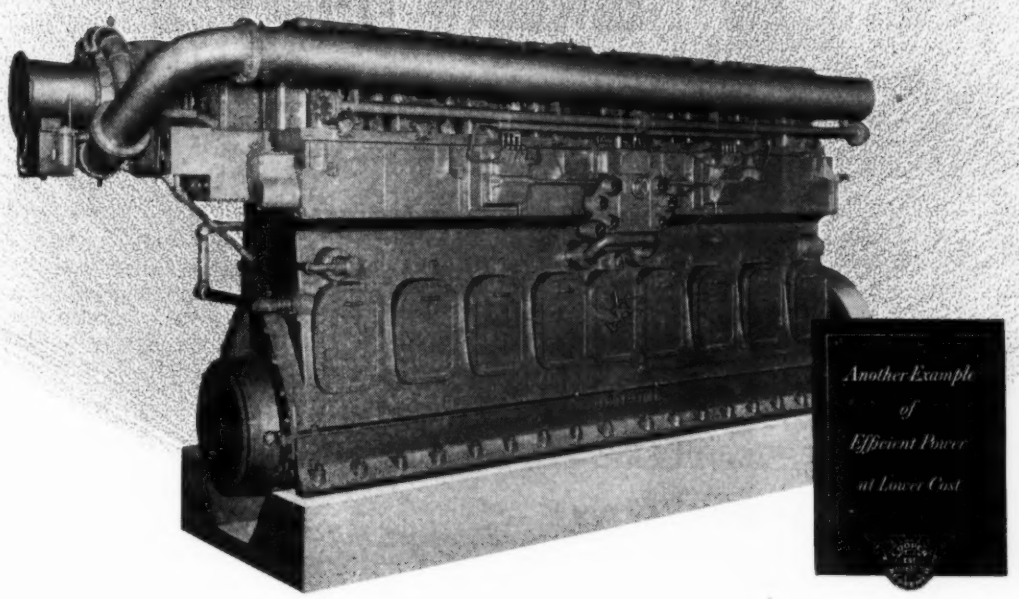
During the war, as a captain in the

Announcing

Cooper-Bessemer

SUPERCHARGED 4-CYCLE GAS ENGINE

100% gas fuel operation!



COOPER-BESSEMER takes great pleasure in announcing the completely successful development of a type of engine that has been a challenge to the industry ever since the advent of supercharging. It makes possible tremendous savings wherever gas is used as engine fuel.

Like ordinary gas engines, Cooper-Bessemer *supercharged* 4-cycle gas engines are spark-ignited, requiring no pilot oil charge. However, they offer at least 50% higher thermal efficiency, consuming less than 7,000 BTU per horsepower hour — easily a 30% saving in fuel.

Moreover, by successfully increasing brake-mean-effective pressure from the usual 70 pounds to 125 psi, the new supercharged engines produce 80% more horsepower. Thus any power need can be met with fewer or smaller engines, permitting additional big savings in installation, housing, piping, maintenance and normal operating overhead.

For further data, for specific information on what this new development offers in meeting your particular needs, check with the nearest Cooper-Bessemer office.

The* Cooper-Bessemer *Corporation

MOUNT VERNON, OHIO — GROVE CITY, PENNA.

New York City Washington, D. C. Bradford, Pa. Parkersburg, W. Va.
San Francisco, Calif. Houston, Dallas, Greggton, Pampa and Odessa, Texas
Seattle, Wash. Tulsa, Okla. Shreveport, La. St. Louis, Mo. Los Angeles, Calif.
Caracas, Venezuela Gloucester, Mass. Calmes Engineering Co., New Orleans, La.

Chemical Warfare Div., he helped design and supervise the erection of the Huntsville Arsenal, Ala., for which he was awarded the Army Commendation Ribbon for Meritorious Service.

BS&B Wins Annual Report Award

For the third consecutive year, Black, Sivalls & Bryson, Inc., Kansas City, has won the bronze "Oscar of Industry" presented by Financial World for the best annual report of the materials handling equipment industry. The trophy was presented to Arthur J. Smith, president of BS&B Oct. 31, in New York.

Covering all the usual information presented in annual reports, this booklet also includes an interesting story of the petroleum industry and the role the company played in its history.

Pittsburgh Coke Opens Tulsa Office

The Protective Coatings Div., Pittsburgh Coke & Chemical Co., has opened a new office at 711 Thompson Bldg., Tulsa, to serve the Central Midwest. Frank E. McNulty, formerly manager of the Koppers Co.'s Tulsa office, has joined the staff as manager.

Appointment of Benjamin H. Means as service manager of Protective Coatings for the entire United States has also been announced. Mr. Means has been handling Pittsburgh Coke's coating sales and service in the Houston area for the past year.

Other Personnel

Elliott Co.—Harry A. Erb has rejoined the firm as assistant to M. A. King, vice president in charge of engineering, with headquarters at the main plant in Jeannette, Pa. Mr. Erb came with Elliott in 1928 following graduation from Cornell. For the past six years he has been steam turbine department service manager for Worthington Dump.

C. H. Hosterman, formerly manager of Elliott's accessories department, has been appointed manager of the general apparatus department, which handles sales of accessories, heater, condenser, and ejector divisions.

Flexitallic Gasket Co.—Two distributors for the state of California have been appointed recently. Power Engineering and Equipment Co., 131 N. Marine Ave., Wilmington, will serve southern California, including San Luis Obispo, Kern, and San Bernardino counties. Northern California will be served by Transmission Engineering Co., 53 Stevenson St., San Francisco 5.

Monsanto Chemical Co. — Charles Allen Thomas, executive vice president since May, 1947, has been elected chairman of the company's Executive Committee, replacing William M. Rand, Monsanto's president, who remains as a committee member. Dr. Thomas, a former president of the American Chemical Society, is one of the small group of scientists to receive the Medal of Merit from the Secretary of War for his work in the field of atomic energy.

Columbia Chemical Div., Pittsburgh Plate Glass Co.—Arthur E. Bald, Jr., has been appointed technical representative, rubber pigments, with headquarters at 1410 Packard Bldg., Philadelphia 2. He formerly was connected with Enjay Inc., specializing in butyl and nitrile rubbers.

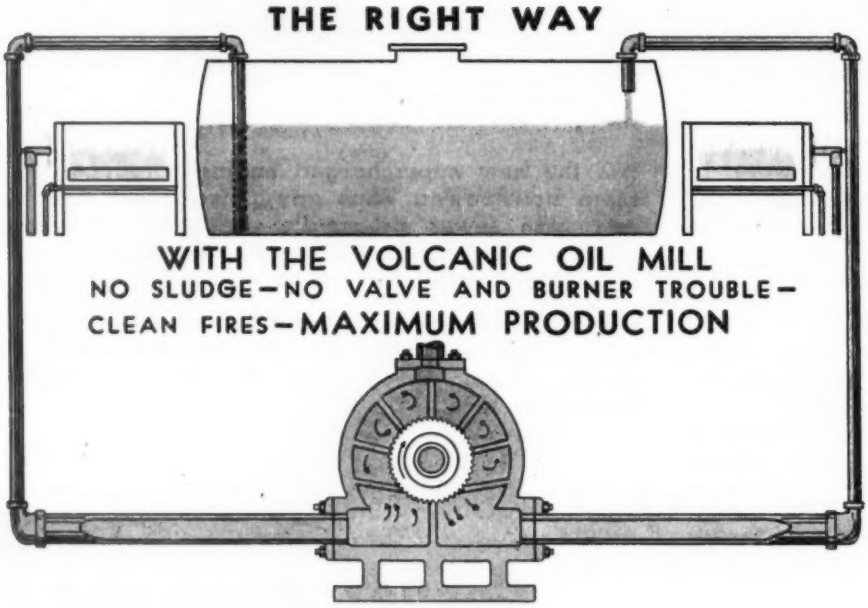
General Refractories Co. — Three men have figured in recent transfers. Roger W. Braden has moved as manager of Detroit warehouse to manager of New York warehouse. Dewitt C. Clement, Jr. and Alan R. Eakins shifted from estimating department to New York warehouse sales force.

TWO WAYS OF BURNING OIL

THE WRONG WAY

SLUDGE IN STORAGE—VALVE AND BURNER TROUBLES—
UNBURNED OIL—LOST PRODUCTION

THE RIGHT WAY



WITH THE VOLCANIC OIL MILL
NO SLUDGE—NO VALVE AND BURNER TROUBLE—
CLEAN FIRES—MAXIMUM PRODUCTION

You can get complete details for a 3c stamp—try it!

HOPKINS' VOLCANIC SPECIALTIES

ALLIANCE, OHIO

What's New!

EQUIPMENT . . . MATERIALS . . . PROCESSES . . . LITERATURE

Reviewed by WILLIAM C. UHL, Equipment Editor

1—Trap Capacity Increased

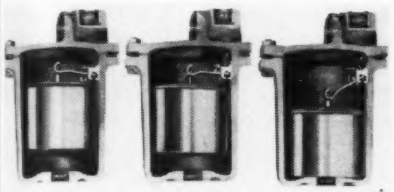


FIGURE 1. Shows orifice closed

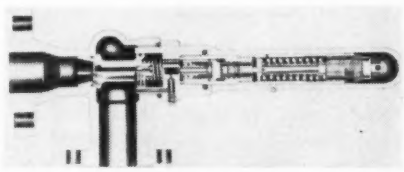
FIGURE 2. First fulcrum point "cracks" orifice

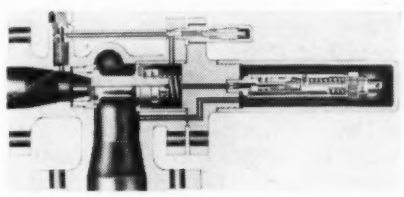
FIGURE 3. Second fulcrum point moves valve from orifice

A new development in steam trap construction, called "Duo-Step Leverage" uses a double fulcrum point and a venting mechanism to increase trap drainage capacity so that it may handle twice the condensate formerly possible. This will mean the users can buy smaller, less expensive traps to accomplish the same drainage jobs previously requiring larger traps, it is stated. Clark Mfg. Co.

2—Pressure Relief Valves

Utilizing line pressure to open and close the main plunger and featuring high relieving capacity and precision control of blowdown, two new pressure relief valves, designated as Garrett Type "A" and Type "B", are now available in all standard sizes for any specified working pressures. Type A, (above in accompanying photographs) is designed principally for hydraulic service and is recommended for use on crude and product lines where long blowdown is usually desirable. Type B (below in the photographs) is intended for refineries, processing plants, and other systems where utmost accuracy is required. It is designed for operating temperatures up to 750° F. Both valves have snap-action controls, assuring full open or closed position of the main plunger at all times, with no chatter. Bodies are cast steel, with Inconel or Monel trim. Sales Engrg. Co. of Houston, Inc.



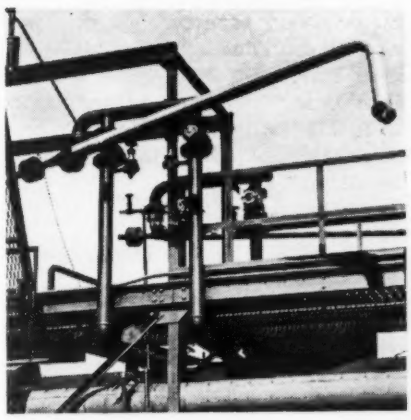


3—Potent Gas Odorant

The new "Calodorant 'C'" compound for providing an easily detected odor in gas has been developed primarily to save handling and servicing costs by gas distributing companies. The manufacturer's present product, "Calodorant," is generally added in the proportion of 13 lbs./million cu. ft., while the new material is equally effective when the proportion is only 0.5 lb./million cu. ft. It is said to be instantly detectable at distances as great as 60 miles of transmission lines, is not nauseous, and is completely unrelated to any other odors. Oronite Chemical Co.

4—Tank Car Loader

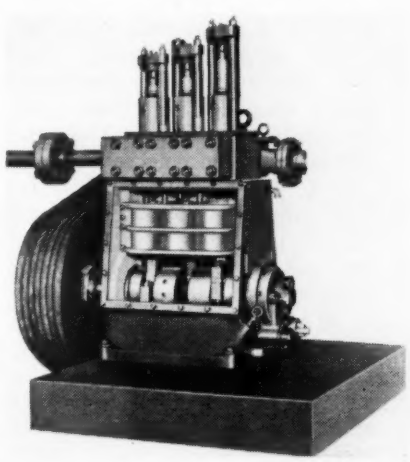
Filling of tank cars has been expedited and worker fatigue lessened on the loading racks at Ohio Oil Co.'s new Robinson, Ill., refinery, it



is said, through the use of a newly designed all-aluminum swing line. With a length of 12 ft., and diameter of 4 in., it is fabricated with "Tube-Turn" aluminum welding fittings. The discharge end is equipped with a Tee, so that oil is directed to both ends of the tank car, to increase filling efficiency. Weight of the entire assembly is approximately 42 lbs. Fabricated in the conventional way, it would weigh approximately 129 lbs., the manufacturer states. Tube-Turns, Inc.

5—Refinery Pumps

A number of new features of design and construction are incorporated in the series of 5-in. stroke Direct Flow pumps just announced by Aldrich, and designed to handle prac-

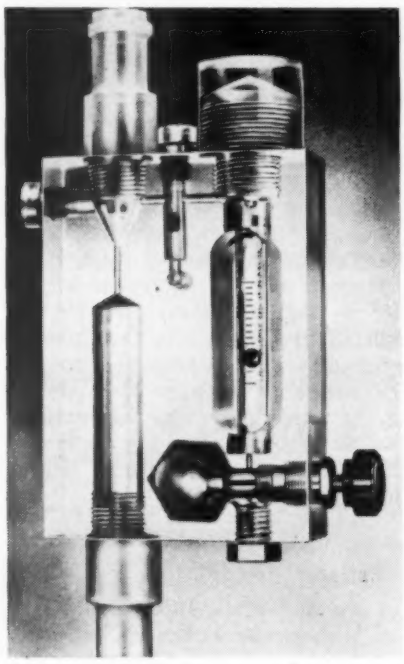


For More Information

Use one of the attached reply cards to request additional information or literature on any items reviewed in "What's New!" Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the rest of the card, and drop it in the mail. No postage required.

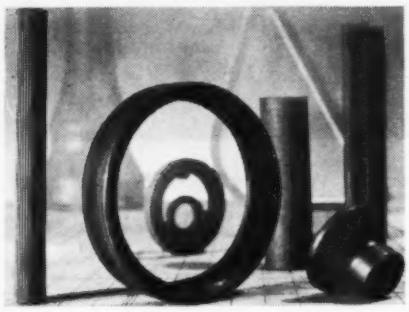
tically all liquids from light ends to crude. The fluid end has stuffing boxes located at the top of the pump. With close clearance for handling light liquids, the end is sectionalized, assuring minimum replacement cost and time requirements when corrosive liquids are being handled. Valve assemblies including seats are held in place by the bolted manifolding, permitting easy access. Two sizes of fluid ends are available to make possible the use of plungers ranging from 1¾ to and including 3½ in. in diameter. Any type prime mover and drive connections are possible. The series includes 3, 5, 7, and 9 cylinder pumps, with hp. ratings from 100 to 275. All wearing parts except main bearings are interchangeable. The Aldrich Pump Co.

6—Chemical Feeder



The "Feed-Rator" is a compact, self contained chemical feeder of transparent acrylic plastic material which will simultaneously control, meter, and dispense relatively small amounts of bactericides, fungicides, inhibitors, reagents, or other chemicals into a larger stream. The built-in eductor takes the place of a pump, and many corrosive chemicals can be fed directly from a container. Measuring about 10 x 5 x 2 in. overall, the unit will, for example, treat up to 7000 gals./day of water directly. In a bypass arrangement, using a solution containing 5% active reagent by weight, 5 ppm. of the reagent can be delivered to over 14 million gals. of water per day. Fischer & Porter Co.

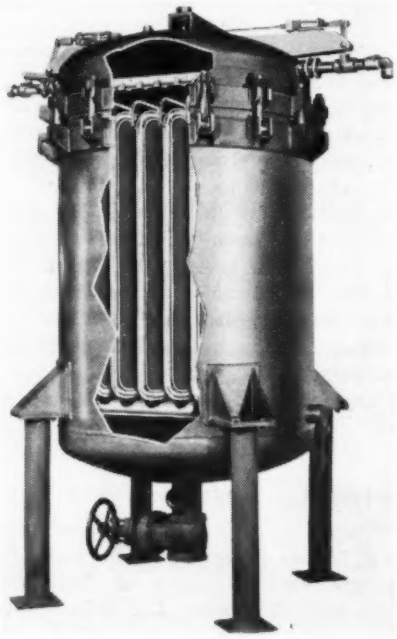
7—Chemical-Resistant Rubber



"Stallite 863" is a new rubber compound with high resistance to the chemical action of acids, alkalies, steam, acetone, benzene, aniline, ethyl chloride, and also withstands extreme weathering, sunlight and dry heat. It has flex and abrasion resistance and dielectric properties. It can be furnished in molded, extruded, and die-cut parts such as seals, gaskets and washers, tubing and hose, and the like. Stalwart Rubber Co.

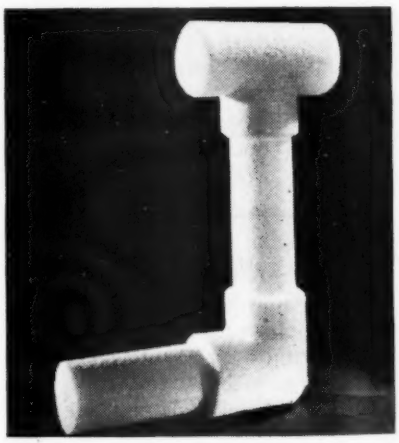
8—Self-Cleaning Filter

The new Niagara "Auto-Sluice" Filter contains a header built into the filter cover in which high pressure spray nozzles are fitted. It permits completely automatic cake removal and disposal, eliminating the need to open the filter at the end of each cycle to sluice the cake from the leaves. Air-motor driven, the header and nozzles are positioned so sluicing liquid is sprayed over the cake of each leaf. Tests show cakes of up to 35 cu. ft. can be removed in as little as 15 minutes with 70 to 100 cu. ft. of wash liquid. Filters are available in sizes from 120 to 500 sq. ft. of filter area, and built in steel, stainless steel, or various alloys. Niagara Filter Corp.



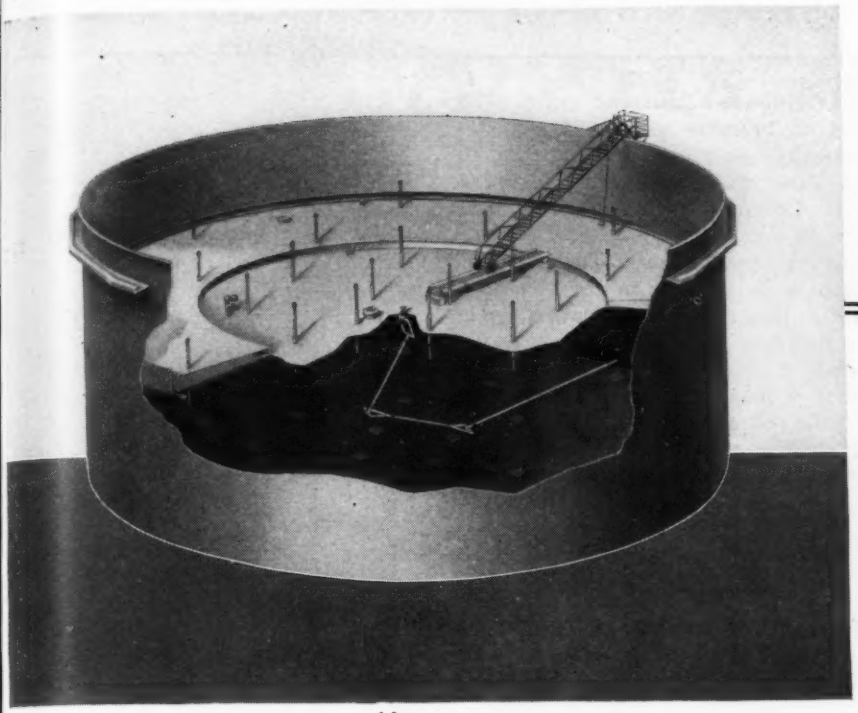
9—Cold Pipe Insulation

Made of an expanded plastic material containing thousands of minute closed-wall cells, "K-Shield" insulation has been developed for low temperature insulation of pipes and vessels in refining, chemical processing and the like. In field applications it has been used in the range from +175 to −250° F., and required little or no maintenance. Extremely light—1¼ to 1½ lbs./cu. ft.—it is a workable yet rigid material with high moisture-vapor resistance and ability to withstand mold growth, rot, and decay. It can be cut and fitted rapidly with ordinary tools, and requires no vapor seal coating. It is made for all standard pipes and fittings, and custom fabricated to specifications for tanks, pumps, and other non-standard items. Robinson Industries.



10—Standard Hydrocarbons

A new series of hydrocarbon mixtures of known composition are now available, designed for standardizing equipment, checking calibration of infrared, ultraviolet, and mass spectrometers, and low-temperature fractionation equipment, and for testing the accuracy of laboratory analysts. Exact blend compositions, accurate to within ±0.05 wt.-%, are furnished with each order. Mixtures are shipped in one-qt. steel cylinders. Price is $25.00 per qt., f.o.b. Borger, Texas, plus a refundable cylinder deposit of $7.50 each. A rental charge of 50c per month beginning six months after date of shipment will also apply. Phillips Petroleum Co., Chemical Products Dept.



the HORTON PONTOON Floating Roof

Another Horton Design for protecting volatile hydrocarbons

The Horton PONTOON Floating Roof is used on flat-bottom storage tanks to protect crude oil, gasoline, and other volatile hydrocarbons from evaporation loss. It floats directly on the surface of the liquid in the tank. The elimination of the vapor space does more than stop "breathing" and "filling" losses. It also reduces corrosion on the underside of the roof and does away with the combustible vapors that could cause a fire. Furthermore, the PONTOON design cuts down evaporation losses caused by "boiling" because the air space in the pontoon section serves as an effective insulating medium for over half of the area of the tank.

The economical design, the effective product protection, and the safe operation that you get with the PONTOON Roof make it desirable for use on petroleum refining or processing installations. This roof is especially recommended for tanks that are filled and emptied frequently, tanks in blending service and tanks storing corrosive products.

OTHER TYPES

• the Horton DOUBLE-DECK Floating Roof—
used on tanks storing a wide range of volatile hydrocarbons, because it provides insulation for the entire surface of the liquid in the tank.

• the Horton PAN-TYPE Floating Roof—
normally installed on tanks handling heavier petroleum products where "boiling" losses are not an important factor and fire protection is desirable.

All three types of Horton Floating Roofs are equipped with the improved Horton Seal—*the most effective device developed to prevent the escape of vapor around the edge of a floating roof.*

CHICAGO BRIDGE & IRON COMPANY

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PENNSYLVANIA

Atlanta 3 .....2103 Healey Building
Birmingham 1 .....1527 North Fiftieth Street
Boston 10 .....1029–201 Devonshire Street
Chicago 4 .....2114 McCormick Building
Cleveland 15 .....2215 Guildhall Building
Detroit 26 .....1532 Lafayette Building
Houston 2 .....2130 National Standard Building
Havana .....402 Abreu Building
Los Angeles 14 1526 General Petroleum Building
New York 6 .....3310–165 Broadway Building
Philadelphia 3....1630–1700 Walnut St. Building
Salt Lake City 1 1530 1st Security Bank Building
San Francisco 11 ..1208–22 Battery St. Building
Seattle 1 .....1330 Henry Building
Tulsa 3 .....1620 Hunt Building

REPRESENTATIVES AND LICENSEES

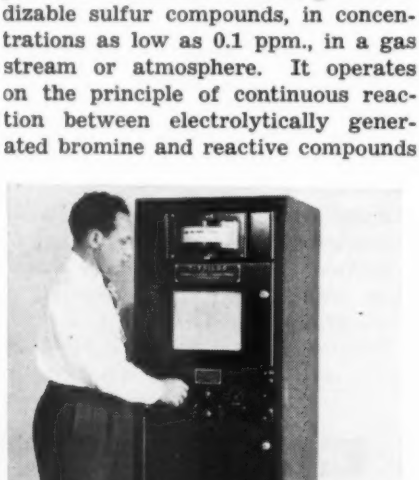
Horton Steel Works, Limited, Fort Erie, Ontario, Canada
Ateliers et Chantiers de la Seine Maritime, Paris, France
Constructions Metalliques de Provence, Arles-sur-Rhone, France
Compania Tecnica Industrie Petroli, Rome, Italy
Whessoe, Limited, Darlington, England
Motherwell Bridge & Engineering Company, Limited, Motherwell, Scotland
Chicago Bridge & Iron Company, Ltd., Apartado 1348, Caracas, Venezuela

11—Collapsible Hand Truck

Folding or opening like and accordion to a full height of 42 in., the "Bestype Fold-A-Way" hand truck can carry up to 700 lbs., though it weighs only 25 lbs. Ten such trucks can be stored in the space formerly required for two of the rigid type, it is stated. A pair of glider bars along lower back edge of the pantograph handles permits moving a load up or down stairs. Truck is available in two models, for straight packages and for drums, barrels, etc. Price, $25.50 each, F.O.B. Elizabeth, N. J. Business Equipment Specialists.

12—Continuous Sulfur Analyzer

The new "Titrilog, Model 26-102" permits continuous recording of oxidizable sulfur compounds, in concentrations as low as 0.1 ppm., in a gas stream or atmosphere. It operates on the principle of continuous reaction between electrolytically generated bromine and reactive compounds to a potentiometric end point. The rate of bromine generated is automatically controlled to equalize it to the rate of absorption of reactive gas. The generating current, therefore, is a function of the sulfur compound concentration. The Titrilog response to changes in concentration is such that maximum titration levels are reached in 20 seconds. The instrument has been field tested for about a year on gasoline monitoring and air pollution applications. Housed in a floor-mounted cabinet 66 in. high, 22½ in. wide, and 18½ in. deep, it operates on 60 cycle, 115 v. power, requiring approximately 6 amps. Consolidated Engineering Corp.

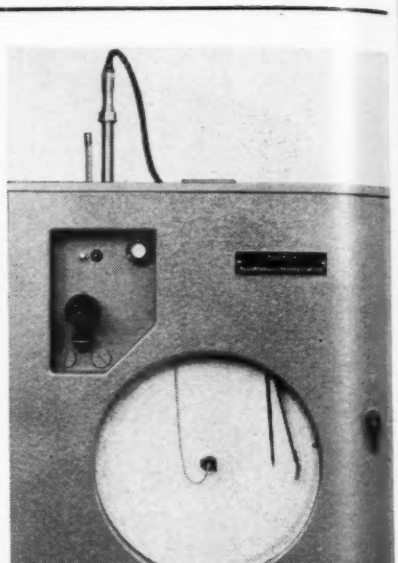


13—Tank Car Unloader

Weighing less than 10 lbs., the new Cornell universal tank car unloading fitting is said to allow a hook-up to be done in less than one minute. One man can easily lift it in place and tighten the collar by hand. Made of cast aluminum, the fitting has high tensile strength, and has met tests for handling liquids under most pressures and conditions. It is available in lengths of 10 and 15½ in., has a standard thread for tank car outlets, and is supplied in both 3 and 4-in. outlet pipe thread for connecting to unloading lines. Mead Cornell & Co.

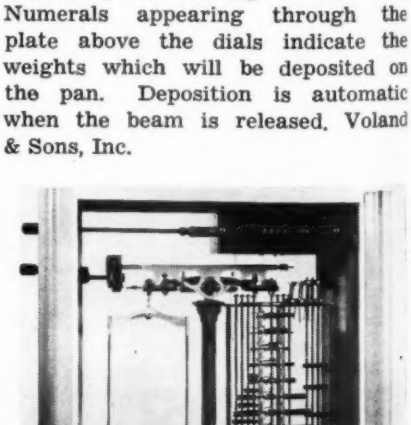
14—Controlling Refractometer

The "Robomatic" Refractometer controls the flow of process streams by refractive index and can be used in any plant where liquids clear enough to provide a refractive index are produced or combined. It covers the entire range from 1.32539 to 1.54409, controlling to within three parts in the fifth decimal place. In operation, process liquid is pumped into a constant temperature bath surrounding the prism. A sodium light behind the bath sends light through the liquid to the eyepiece and also to a photoelectric cell, whose responsive action actuates a recording pen and any subsequent air-operated control mechanisms. The bath has a range from 35 to 150° F., accurate within 0.02° F. The instrument is constructed for flush mounting and is 19 in. deep, 34 in. high, 24 in. wide. It was developed in conjunction with Dow Chemical Co. by Precision Scientific Co.

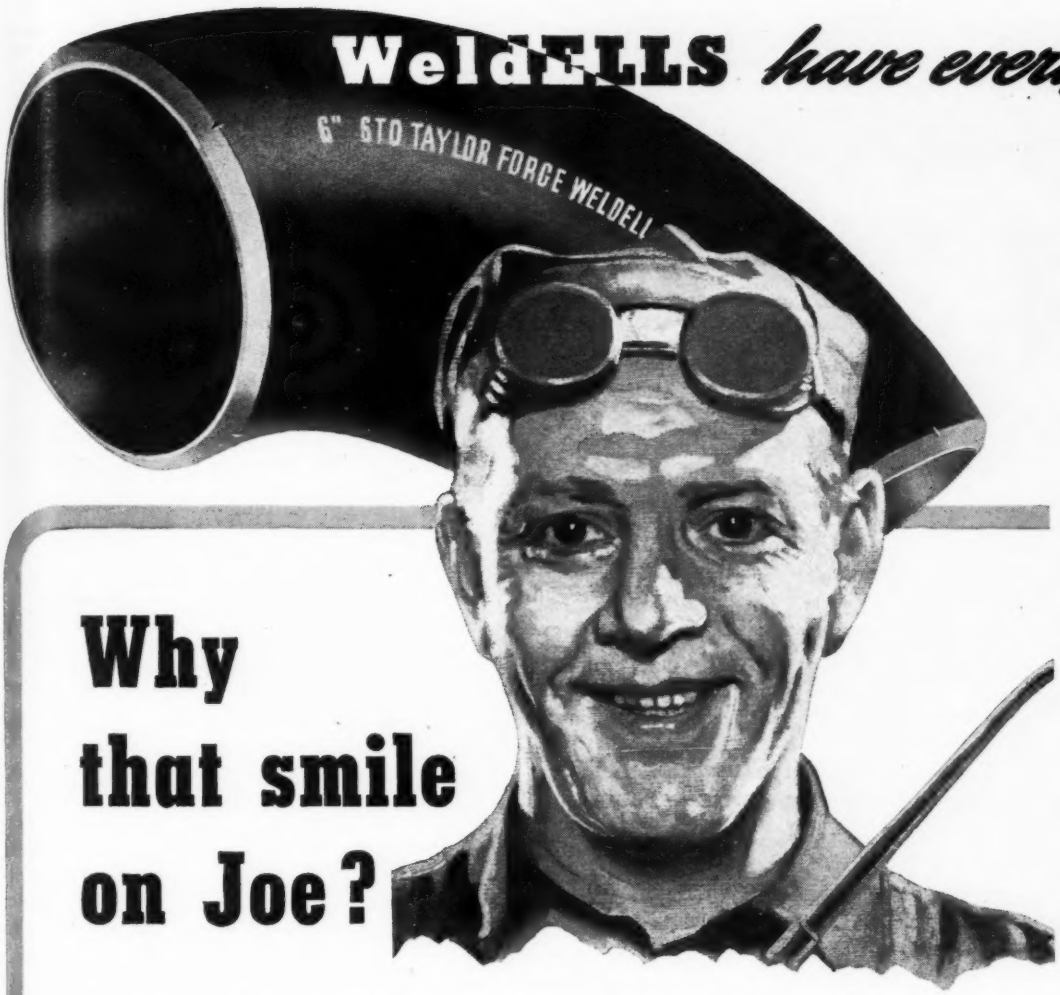


15—Rapid Analytical Balance

The "Speedigram" analytical balance is said to permit untrained personnel to achieve weighing times of less than two minutes, without the use of computations or interpolation. It is expected to prove useful for weighing samples of volatile materials. The balance reads directly up to 100 grams without weights, but has an extra 100 gm. weight supplied. Sensitivity is 0.05 mg. at full load. Numerals appearing through the plate above the dials indicate the weights which will be deposited on the pan. Deposition is automatic when the beam is released. Voland & Sons, Inc.



WeldELLS *have everything...*



Why that smile on Joe?

Joe may not know much about the engineered strength of WeldELLS, or the metallurgical control, or the greater scope of the WeldELL line. However, it is plain enough that these considerations which mean so much to you begin to lose meaning unless Joe does *his* part of the job right.

That's why we designed WeldELLS, not only for you, but also for Joe. That's why Joe smiles: A good Welder like Joe takes extra pride in the kind of job he can turn out when it's made easy for him by these easily identified fittings, with sized end tangents, cleanly machined bevels, precision quarter markings to speed lining up, accurate key dimensions, plus other conveniences that are combined only in WeldELLS.

Yes, Joe does a better job with WeldELLS . . . and in the final analysis, *your* work rests on Joe's work!

Remember that the line which offers the most to both you and Joe, also contains the most complete range of sizes, thicknesses, and types of fittings, *and* in a complete range of materials. Convenient stocks are carried in all industrial centers.

Note these features that appeal to the man on the job:

No guess-work; markings clear and complete.

Precision quarter marks mean a lot to the welder.

Extreme accuracy, uniformly maintained.

Sized end tangents.

Cleanly machined bevels.

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STALWART Custom-Fabricated oil and gasoline—resistant rubber parts can be supplied to meet S.A.E. or individual specifications in the automotive, aviation, petroleum, electrical, chemical processing and many other industries.

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THERMOWELLS

Standard Test Wells

Type T-190 Series TRINITY Standard Test Well

T-190 — 1" SPT-7/16" bore for etched stem, bi-metal test, or armor clad thermometers, or any primary element with diameter not over 0.427"

T-191 — 3/4" SPT — 7/16" bore for same.
T-192 — 1/2" SPT — 7/16" " " "

Sizes: 2", 4", 6", 8", 10", 12", 15" and 18" immersion length. Special orders up to 36" (T-190 and T-191 only).

Wall thickness: 0.219" (T-190); 0.187" (T-191); 0.094" (T-192).

Lagging extension available.
Plug & Chain regularly furnished.

* * *

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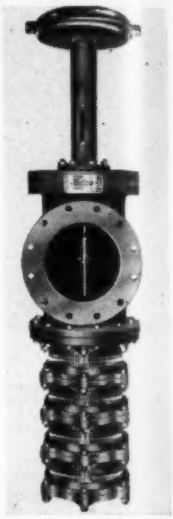
THERMOWELLS and Other Specialties for the Process Industries

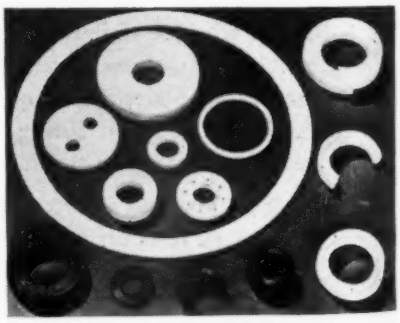
What's New!

16—Water Treatment Valve



The "Belco" Atomizing Valve, a proportioning type, has been developed for use on deaerating heaters, vacuum deaerators, and hot process water softeners. It is designed to provide a tangential spraying action and atomization of incoming water to droplet form. Tests have shown "zero" oxygen after atomization in a steam atmosphere without the use of reboilers or scrubbers. It has an external stem and is diaphragm operated, being actuated either by a float cage pilot or differential orifice. Sectional design permits increasing the capacity of existing equipment by adding more sections. Liberal clearances and port openings eliminate any possibility of clogging due to turbid water supplies or scaling due to high bicarbonate hardness in the water supply. The valve is available in all capacity ranges up to 2000 gpm. Belco Industrial Equipment Division, Inc.

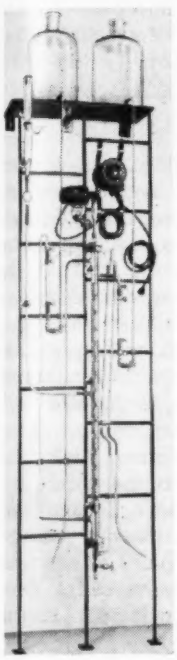
17—Chemically Inert Packing



"Chemlon," an inert plastic packing material effective up to 450° F., is available now in molded form in a variety of shapes. It was previously furnished in braided packing. Molded forms now furnished include washers, bushings, rings, self sealing "V" cross-section rings, ring gaskets, and jacketed gaskets. It is not attacked by any acids or alkalies, and is highly flexible. This is helpful in installing rings. When split, they can be twisted and placed directly on the shaft without removing the gland completely. The material also has high insulation properties. Crane Packing Co.

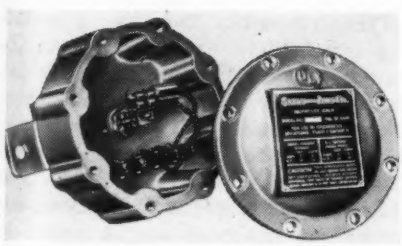
What's New!

18—Laboratory Extractor



In the York-Scheibel continuous laboratory solvent extraction unit, the best features of both solvent extraction and fractional distillation have been combined by use of a column in which mechanically agitated mixing sections are separated by packed settling sections. The height of the column has no effect on the extraction stage efficiency, and the effect of the diameter on the height of a theoretical stage in the column is no greater than the corresponding effect on the height of a theoretical plate in a distilling system. Thus, plant scale processes are no longer limited to 5 or 6 theoretical stages: 50 or 60, or more, are not only possible in one column, but have proved to be practical and economical. The picture shows a unit with a one-in., 14-stage column, complete with all auxiliary equipment, available from stock. Larger pilot and plant scale units built to order. Otto H. York Co., Inc.

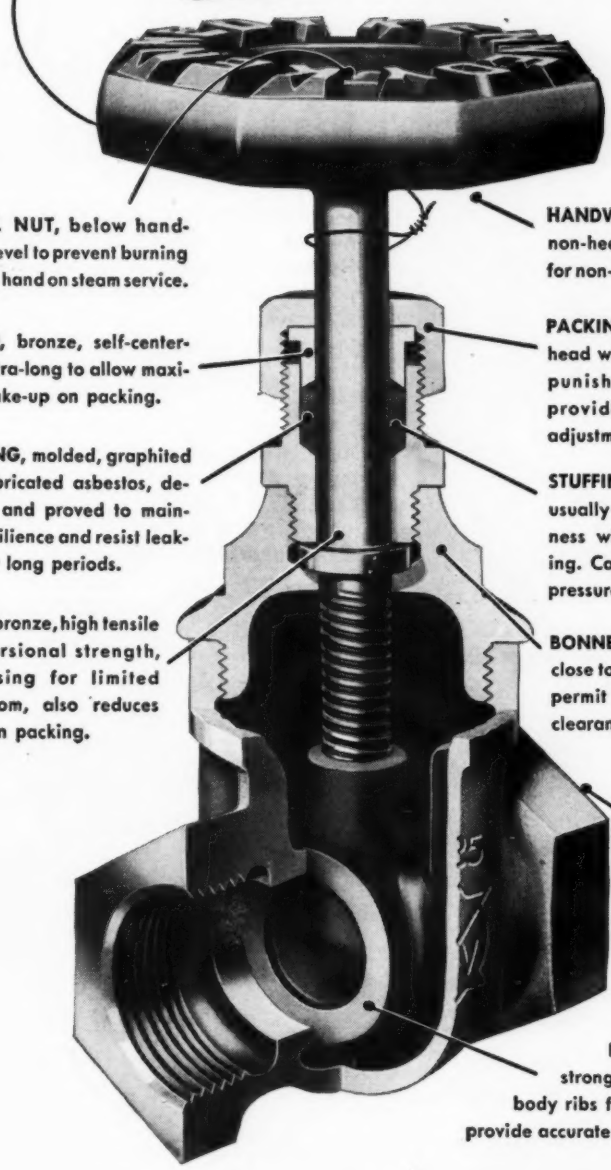
19—Safe Switch Box



An explosion proof switch box, designed for mercury tube switches, now is available and has been listed by Underwriters' Laboratories for use in Class 1, Group D locations, in ambient temperatures up to 155° F. Body and cover are of cast aluminum. Provided with mounting flanges, the body measures approximately 9½ in. long by 5¼ in. deep. A threaded hub accommodates a stainless steel operating shaft for the mercury tube electrodes. All terminal connections are accessible when cover is removed. A ½-in. threaded outlet provides for conduit connection. Shand & Jurs Co.

Design and Engineering Put EXTRA Value In This KENNEDY VALVE

KENNEDY STANDARD BRONZE GATE VALVE, FIG. 27, non-rising stem. Conservatively rated for services up to 125 Steam, 175 Water, Oil or Gas. ¼" through 3" sizes available.



WHEEL NUT, below handwheel level to prevent burning palm of hand on steam service.

GLAND, bronze, self-centering, extra-long to allow maximum take-up on packing.

PACKING, molded, graphited and lubricated asbestos, designed and proved to maintain resilience and resist leakage for long periods.

STEM, bronze, high tensile and torsional strength, non-rising for limited headroom, also reduces wear on packing.

HANDWHEEL, malleable iron, non-heating design, large size for non-slip, comfortable grip.

PACKING NUT, bronze, heavy head withstands pipe wrench punishment, extra threads provide increased packing adjustment.

STUFFING BOX, bronze, unusually deep to provide tightness without jamming packing. Can be repacked under pressure wide open.

BONNET, bronze, large hexes close to body increase rigidity, permit easier removal when clearances are close.

BODY, bronze, rugged construction, straight passageway minimizes flow resistance, disc clears passageway in full open position.

DISC, bronze, simple, strong mechanism. Interior body ribs fit channels on disc to provide accurate guide.

Write for Bulletin No. 102 • **BUY FROM YOUR LOCAL DISTRIBUTOR**

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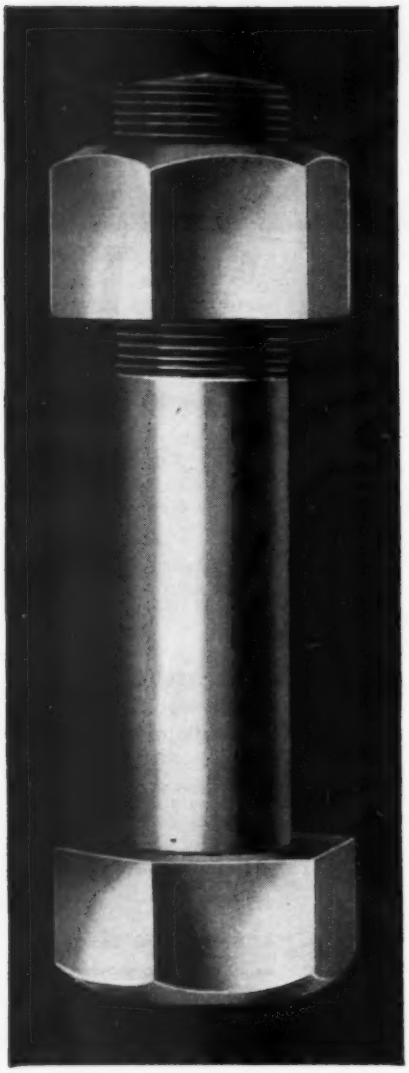
VALVES • PIPE FITTINGS • FIRE HYDRANTS

OFFICE-WAREHOUSES IN NEW YORK, CHICAGO, SAN FRANCISCO • SALES REPRESENTATIVES IN PRINCIPAL CITIES



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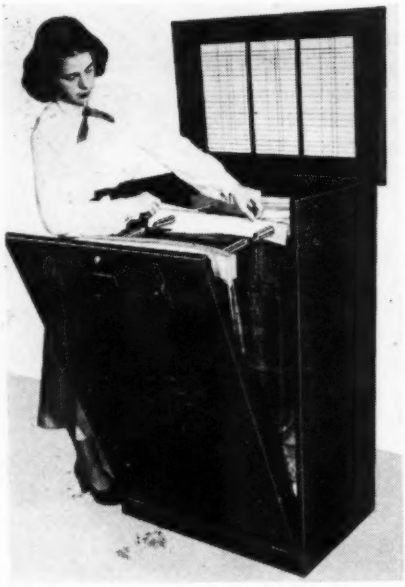
"REPRESENTATION IN PRINCIPAL CITIES"

What's New!

20—Explosion-Proof Sump Pump

The fully enclosed, explosion-proof motor and switch on the new Penberthy Series MC sump pump have Underwriters' approval for such hazardous locations as gasoline, naphtha, alcohol, acetone, solvent vapors, natural gas, and various dusts. Motor lead connections follow requirements of the National Electrical Code. Pump has a nominal capacity of 4000 gals./hr., and 23-ft. discharge head. Construction is copper and bronze throughout. Switch is controlled by copper float with an adjustable stop for governing water level. The pump is built in five lengths for depths of 2, 3, 4, 6, and 8 ft. It is available from stock for 110 or 220 volt, 60 cycle operations; other current characteristics can be supplied. Penberthy Injector Co.

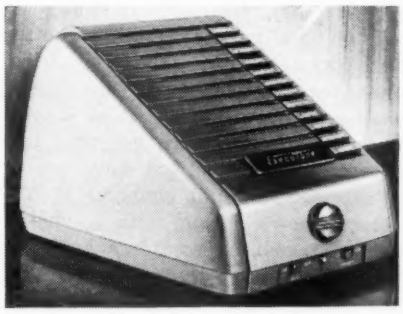
21—Blueprint Cabinet



The "Draw-In-Dex" cabinet files blueprints, drawings, photo blowups and the like, up to 48 x 72 in. in size, without wrinkles, creases, or curled and torn edges. The cabinet, 4 ft. high x 2½ ft. wide x 20 in. deep, accommodates up to 1000 prints. An index file locates desired drawings instantly. Any print can be removed without disturbing the others. Delivery is said to be immediate. Price is $139.50, fob. New York City. Empire Development Corp.

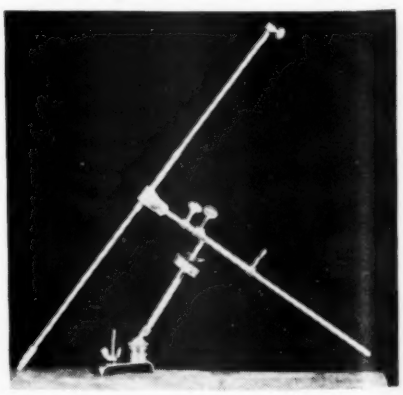
22—Intercom System

"Chime-Matic" signalling, a part of a new intercom system, is said to simplify and speed up call-origination. Pressing any button automatically announces the call at the station selected by a chime and a signal light. The caller does not have to press the talk bar, or announce himself. The individual being called does not have to "match buttons" with the station calling. Electronic circuits minimize high and low frequency background noises and so-called key clicking. Design permits as many simultaneous conversations as there are pairs of stations, and also protects conversants from eavesdropping or cutting-in. Executone, Inc.



23—Pattern-Making Device

The "SMW" Pattern Maker, a modified, parallel-leg compass with an adjustable radius bar, has a scribe-leg which slides in a bearing on the radius bar to project desired shapes on any surface. It is said to reduce day-long jobs to a matter of minutes, and enable the average sheet-metal worker or welder to solve in a few moments most pattern problems encountered in sheet metal work or pipe fitting. It is priced at $7.50, postpaid. E. A. Scott.



What's New!

24—Catalytic Gas Processes

Three expanded "Deoxo" processes for the catalytic purification, hydrogenation, and oxidation of gases have been introduced as the result of newly developed Engelhard catalysts, which are said to last indefinitely. The Model "M" Purifier provides for the catalytic combination of oxygen and carbon monoxide to form carbon dioxide in gases not containing hydrogen. It may also be used for oxidation of CO to CO_2 in an H_2-rich atmosphere, or for the oxidation of H_2 in oxygen gas. The second process, the Model "DM", provides simultaneous catalytic combination of CO plus H_2 to CO_2 plus water vapor. Methane and water vapor are formed from CO and H_2 with the Model "E" Deoxo Purifier. Baker and Co., Inc.

Trade Literature

25—Limited NPSH Pumps

BJ "VMT" Pumps, Bulletin 49-6600; describes a line of vertical multi-stage centrifugal pumps designed for hot or cold, corrosive or non-corrosive liquids, where the net positive suction head is limited, in capacities to 1000 and 5000 gpm. Byron Jackson Co.

26—Combustion Control

"Robot-Eye" Combustion Control, Technical Bulletin No. 103; describes the nature of "haze" and its use as a combustion index to actuate a control system for industrial furnaces burning all types of hydrocarbon fuels, together or separately. General Power Plant Corp.

27—Graphic Panel Components

Pneumatic Force Balance for Measurement, Transmission, and Control, Bulletin 509; covers description of component instruments used in the new UOP-designed graphic panel for complete supervision of entire oil refinery, including the "Nullmatic" controller, and the "M/P" control station. Moore Products Co.

28—Threading Stainless Steel

Don't Fear the Threading of Stainless; a folder covering case studies, giving speeds, tool angles, coolants and other pertinent data on how to overcome the problem of poor threads in stainless steels; for example, in valve bodies, castings, and the like. Cooper Alloy Foundry Co.

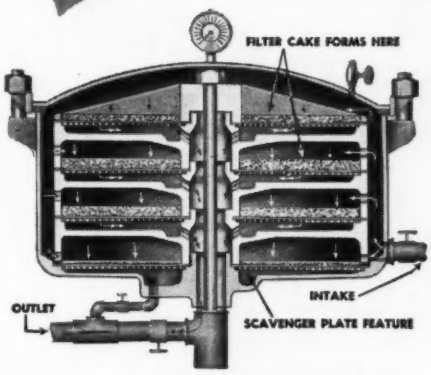
29—Refinery Pumps

Pacific Multi-Stage Centrifugal Pumps, Types J, JH & M, Bulletin

Sparkler Filters

SPARKLER horizontal plate FILTERS

. . . keep petroleum products clean and free of foreign matter



The Sparkler horizontal plate method of filtration insures a firm, unbroken filter cake formed from diatomaceous earth or other filter media particularly suited to the liquid filtered. Such a filter cake removes even microscopic particles from any liquid ranging from light alcohols to heavy resin products.

The petroleum refining and processing industry have available a filter in the Sparkler that solves many problems of keeping liquid petroleum products free from solids such as scale, rust, grit, and other foreign matter.

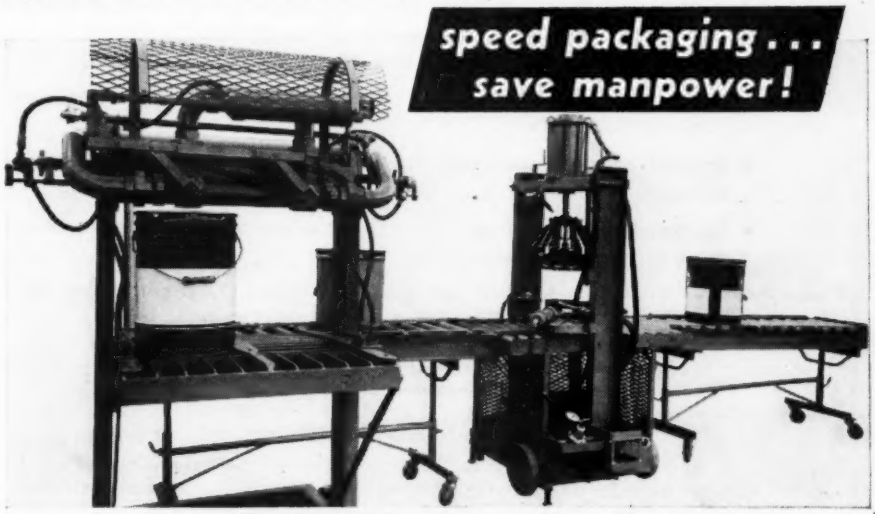
Domestic Fuel Oil bulk plant operators can be sure of delivering clean clog-free fuel oil by filtering with Sparkler filters

Sparkler filters are available in capacities from small pilot plant models to built-in production line units of 5000 gallons per hour. The services of our staff of engineers with over a quarter of a century experience in solving filtration problems is available. Your problems will receive personal attention and individual analysis. Write Mr. W. J. Kracklauer, Sec'y & Treas.

SPARKLER MANUFACTURING COMPANY, Mundelein, Illinois

BARRETT FILLING & CRIMPING MACHINES

speed packaging . . . save manpower!



This portable, air-operated installation enables a two-man crew to fill, seal and stamp, ready for shipment, up to 15 five-gallon (35-lb.) containers per minute. No electrical connections required.

• Handles grease and viscous fluids • Capacities: 5-lb. to 100-lb. standard containers • Custom-built to fit user's individual needs • Precision-machined for trouble-free, long-life operation • Used by leading oil companies • Satisfaction guaranteed.

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Badger IS FIRST IN expansion joints

COMPACT

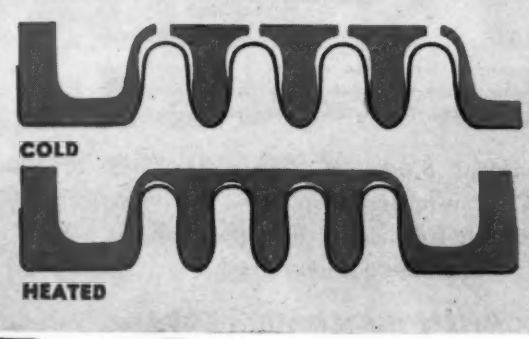
Installation and maintenance are easy — even in the tight places commonly encountered in refinery and petroleum processing pipe lines — when you use Badger Packless Corrugated Expansion Joints. Thanks to thoughtful designing, the outside diameter of any Badger Joint is about the same as an ordinary flange . . . installation is as easy as bolting in a new pipe section . . . space requirements are cut to a minimum.

And here are other features equally important to you:

- Flexible . . . quick response to heat expansion cuts strain on adjacent fittings and equipment.
- Packless . . . single tube construction provides pressure-tight joint without packing.
- Fabricated from stainless steel or alloys . . . joints withstand the high temperatures and corrosion encountered in oil refineries and other petroleum processing plants.
- Controlled Heat Treating . . . assures corrosion-resisting qualities for long life.
- Special forming methods . . . no danger of structure-weakening stresses.
- Directed flexing rings . . . to equalize stresses *between* and *within* corrugations.

These features are important in any pipe line job . . . you can get them all only by specifying Badger Expansion Joints.

Write today for Bulletin 100 (self-equalizing type) or Bulletin 200 (non-equalizing type).



EXCLUSIVE all-curve corrugations equalize stresses

Although free to traverse axially, Badger Expansion Joints are constructed so that the Directed Flexing Equalizing Rings assure an even distribution of stresses whether caused by *temperature, pressure* or *movement* . . . there's no excessive strain at any point.

Badger MANUFACTURING COMPANY
230-260 BENT STREET • CAMBRIDGE 41, MASS.

What's New!

112, and *Single Stage Double Suction Impeller Volute Types D, DC, DH,* Bulletin 107; covering lines of pumps in capacity range of 50 to 3000 gpm. in the multi-stage design and 50 to 12,000 in the single stage type. Pacific Pumps, Inc.

30—Instrument Valves

Edward Forged Steel Instrument Valves, Bulletin 491; comprises dimensions, weights, prices and operating data on a line of valves for instrument, and other small lines, with a rating of 6000 psi. WOG. at 100° F. or 1500 psi. SP. at 1000° F. Edward Valves, Inc.

31—Water Treatment

Corrosion Inhibition in Recirculating Water Systems, eight page reprint of an article covering 1) anodic polarization, 2) cathodic polarization, 3) preventing harmful deposits, 4) removal of corrosive constituents, and 5) adjusting the pH; includes latest experimental data on inhibitive action of various chromate concentrations. Mutual Chemical Co. of America.

32—Float Valve Prices

Keckley Float Valves; a four-page folder covering direct acting and pilot control, single seated and double seated float valves in globe and angle patterns, from ½ to 12 in.; giving prices, shipping weights, etc. O. C. Keckley Co.

33—Processing Equipment

BS&B in the Refining Industry; a 20-page catalog on heaters, separators, scrubbers, dehydrators, chemical feeders, and also safety heads, relief valves, blow cases, mufflers, pipe half soles, and special fabrication; with charts giving capacities and specifications. Black, Sivalls and Bryson, Inc.

34—Stainless Steel Centrifugals

Goulds Stainless Steel Centrifugal Pumps, Bulletin 725.3; eight pages of specifications, drawings, and pertinent data on new line of stainless steel centrifugals with capacities up to 750 gpm., and heads up to 180 ft. Goulds Pumps, Inc.

35—Thermowelds

Trinity Thermowells and Other Specialties for the Process Industries, Catalog No. 200; a 44-page booklet of detail drawings, specifications, etc. on line of thermowells; including a number of special metal coverings —tantalum, Colmonoy, lead, and Stellite—for special requirements. Trinity Equipment Corp.

What's New!

36—Cooling Tower Maintenance

A Blueprint for Operating and Maintaining Mechanical Draft Cooling Towers, a 16-page booklet, with drawings, charts, and graphs, giving the procedure for 1) putting the tower into service, 2) inspection, 3) lubrication, 4) checking efficiency, and 5) partial or total shutdown. C. H. Wheeler Mfg. Co.

37—Corrosion Protection

Corrosion Service Piping, Bulletin 485; 32 pages of economics, standards, welding and technical data, design hints, and dimensional information on stainless and nickel alloy fittings, flanges, and piping; prepared with ASA Standard B36.19-49 as its basis and including explanation of this newly adopted American Standard. Taylor Forge & Pipe Works, Inc.

38—Hydrocarbon Price List

Price List No. 8, Oct. 1, 1949, 12-page booklet covering paraffins, cycloparaffins, olefins, cyloolefins, aromatics, available in four grades—research, pure, technical, and commercial, including prices, containers, shipping data, sales conditions. Phillips Petroleum Co.

39—Processing Equipment

Patterson Chemical and Processing Equipment, Publication CEC-49; a 36-page illustrated booklet lists all process equipment in the line, such as heat exchangers, hydrogenation, gas absorbing, mixing, and many other type units. Patterson Foundry & Machine Co.

40—Stockroom Shelving

Shelving — Rotating and Straight: Folder J-213: describes a line of steel shelving units in conventional straight design and also rotating units, including suggested efficient layouts. Frick-Gallagher Mfg. Co.

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Business reply cards are included in this issue of PETROLEUM PROCESSING to assist you in obtaining more information on any items reviewed in "What's New!" You'll find them facing page 1265. Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the bottom of the card, and drop it in the mail. No postage required.

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For Industrial Furnace Construction
Grade "F"

CHEMICAL COMPOSITION:

(a) The castings shall conform to the following requirements as to chemical composition:

	GRADE "F"
Chromium, per cent	25.0-28.0
Nickel, per cent	10.0-12.0
Manganese, per cent	0.50-1.25
Silicon, per cent	0.25-1.75
Sulphur, maximum per cent	0.05
Phosphorus, maximum per cent	0.05
Carbon	Within limits of Paragraph 4 (c)

(b) The chemical limits for all other added alloying elements, such as molybdenum, titanium and nitrogen, shall be specified by the manufacturer. The material shall conform therewith.

CREEP STRESS AND CERTIFICATE:

(a) The indicated creep rate of the material shall not exceed 1% in 10,000 hours when stressed by a tensile load not less than the following:

TEMP. °F.	STRESS PER SQ. IN. 1% CREEP IN 10,000 HOURS GRADE "F"
1400°	4200#
1500°	3700#
1600°	3200#
1700°	2600#
1800°	1950#

(b) Manufacturer shall submit standard creep data and residual physical properties made on material of his own manufacture and certified by an ACCREDITED LABORATORY. The chemical analysis of the creep test specimens shall be reported, including nitrogen content and any other special alloying elements.

TENSION TEST FOR DUCTILITY AFTER HEATING:

(a) Each heat shall conform to the following requirements as to tensile properties after the specimen has been subjected to a temperature of 1400° F. for 24 hours and furnace cooled to 400° F. Test shall be made at room temperature.

	GRADE "F"
Tensile Strength, min.lb./sq.in.	80,000
Yield Strength, min.lb./sq.in.	35,000
Elongation in 2", min. per cent	9.0

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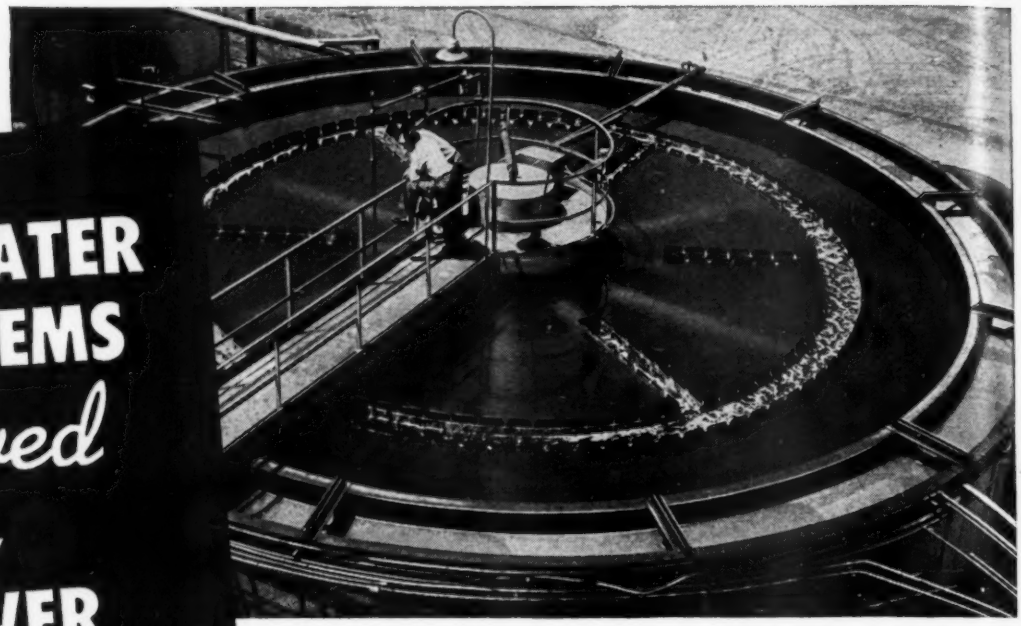

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A representative refinery had a *double* water problem—the conditioning of oily waste water for disposal, and the clarification and softening of a droughty, turbid, hard river water for make-up. In addition, it was also important to eliminate bacteria and algae growths from the water.

An installation of Graver Reactivators and filters now clarifies the waste water and produces an effluent which can be reused in the plant. The requirement for the droughty river water has been reduced to a minimum and clarified waste water discharged into the river produces virtually no pollution. The Reactivators clarify and soften the water by the sludge recirculation and flocculation principles at a cost of a few cents per thousand gallons of water for chemicals, and the installation is compactly arranged so as to be conveniently operated by only one operator per shift. All of the softening and filtering equipment, including the tanks, was specially designed, manufactured, and erected by GRAVER, providing a single responsibility for the entire job.

Write for bulletin describing the GRAVER Reactivator in detail and explaining its many superior features.

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Removal of Dissolved Gases . . . oxygen, carbon dioxide, hydrogen sulfide, ammonia, etc.

For Liquid Processing:

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Recovery of valuable substances from waste or by-product solutions or suspensions
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Gasoline and Cycling Plant Operation

Conducted by DAVE THORNTON

The Question and Answer Editor this month takes the reader along with him to a gasoline plant operator's technical session, the Southern Regional Meeting of the Natural Gasoline Assn. of America, at Tyler, Texas, Oct. 14. Most of the papers were highly practical in nature and the information they contained is presented here in the form of answers to pertinent questions. Additional ones will appear next month.

As always, questions from readers are invited, pertaining to the above or other problems in gasoline plant operation.

Guarding from Explosions In Air Starting Systems

Are explosions in air starting systems peculiar to certain designs or modes of operation and are there any recommendations to minimize this hazard?

The Natural Gasoline Assn. of America recently sent out questionnaires to survey this problem which has plagued the industry for many years. The explosions usually occur at the time of or immediately following the use of compressed air to "roll" the engine.

A total of 15 companies responded, representing operating experience ranging from two to 30 years. Ten companies reported explosions. It is difficult to point out any one type of starting air compressor as being entirely safe, since within these companies are represented practically every make and type that has been or presently is on the market, and the five who did not experience explosions in general have the same variety of equipment.

Operating practice appears to be a more important contributory factor in causing explosions in air starting systems than does compressor design, although certain designs naturally are better suited to preferred safe practices.

Use of a non-combustible lubricant or a minimum quantity of lubricating oil is clearly associated with the least incidence of explosions. Minimum discharge temperature of compressed air decreases the possibility of an explosive mixture with overheated lube oil. Obviously, a high-flash, stable oil is to be preferred for this application.

An important part of compressed air systems is the air receiver. In addition to furnishing reserve air capacity, the air receiver functions to dampen pulsations created by intermittent compressor discharge, permits settling out of condensate and foreign particles in the compressed air and provides additional air cooling. To best satisfy these latter functions, the air should pass through the receivers, entering the side and leaving through a top connection. The purpose of this type of installation is to insure scrubbing and removal of any oil or water which may pass from the compressor. The aftercoolers and air receivers should have drains permitting removal of any excess oil or water at least once every eight hours. The water carried over is distilled and quite corrosive.

The air suction to the starting air compressor should be taken from outside of the building at roof height and located to minimize the possibility of any volatile hydrocarbons being introduced into the air system.

Filters on the air suction line are necessary to keep foreign material out of the air system. Where oil bath filters are used, the job of maintaining and refilling them should not be treated too lightly as serious trouble could ensue if oil from the filter is drawn into the air system. The use of the dry type filter would eliminate this hazard.

Information furnished in reply to the questionnaire and reports from other sources indicate the presence of oil and carbon (possibly active) in compressed air systems. There can be little dispute that the presence of such combustible material in a compressed air system presents a potential hazard. At frequent, regular intervals it would be good practice to remove all such deposits.

I believe in a number of cases that companies which employ the use of splash lubricated air compressors have failed to provide compressors of adequate size, with the result they are forced to run almost continuously. As a result, the compressor operates at higher temperatures causing carboned piston rings and excessive oil consumption. With such continuous operation, proper maintenance often is delayed for long periods. A standby air compressor would make it possible for the regular compressor to be shut down for required inspection and maintenance.

The use of soap as a lubricant, based on the questionnaire, seems to be the best answer for those who desire safe, economical and continued operation. Five companies who have used or presently are using soap as a lubricant in their starting air compressors have never experienced an explosion while using soap exclusively.

Soap lubrication apparently has

Papers Presented at Tyler Meeting

Following are the papers presented at the Southern Regional Meeting of the N.G.A.A., at Tyler, Oct. 14:

"Gas Compressor Lubrication," F. M. McNall and E. H. Flaherty, Clark Bros. Co., Inc., Olean, N. Y.

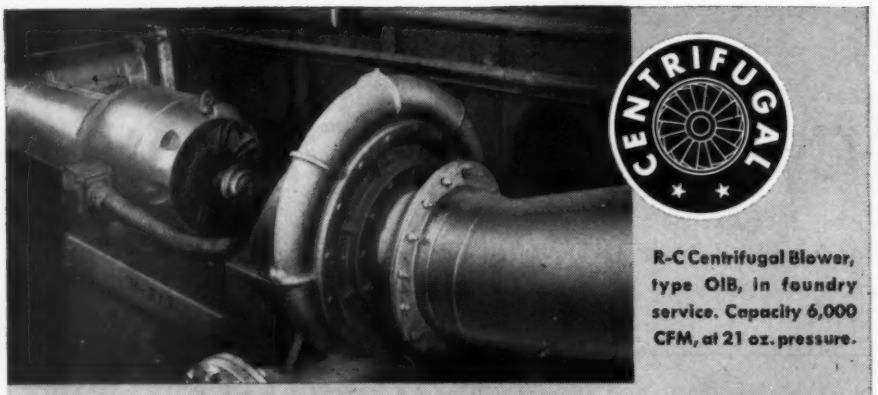
"Explosions in Air Starting Systems," Paul Lindeman, Phillips Petroleum Co., Bartlesville.

"Corrosion Problems in Gas Plant and Cycling Operations," J. H. Nashke, Gas Division, Humble Oil & Refining Co., Houston.

"Operation and Maintenance of Cooling Towers," Neal B. LauBach, Cooling Tower Division, Hudson Engineering Co., Houston.

"Some Practical Considerations in Gasoline Plant Instrumentation," C. F. Woods, Brown Instruments Division, Minneapolis-Honeywell Regulator Co., Dallas.

"The Relationship of Personnel to Plant Efficiency," M. V. Cousins, United Gas Pipe Line Co., Shreveport, La.



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ROTARY

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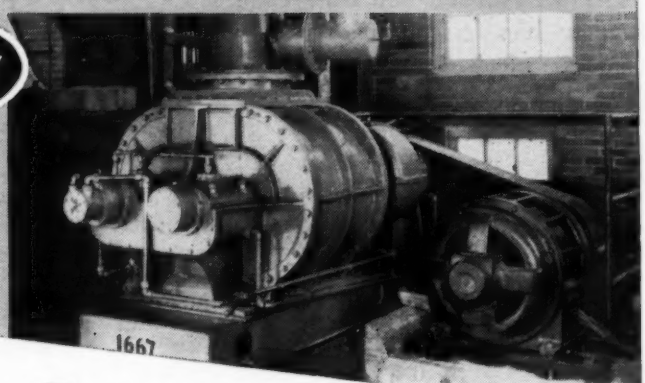

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Questions and Answers

given some plant operators a lot of trouble due to the caking action which the soap has on the working parts of a comperssor. It is quite possible this caking is due to using too much lubrication. Due to the corrosive action of distilled water, it is absolutely necessary that neither the lubricator parts or lines be made of brass. Liquid sight feeds on forced feed lubricators should not be used with soap since there is no way of determining the amount of lubrication pumped to individual compressor cylinders.

One company reported that one of its plants has been using soap for 20 years and has never experienced any lubrication problems, but in another plant with identically the same type of equipment, the operators have yet to obtain satisfactory results on soap lubrication. One probable reason for unsatisfactory experience with soap lubrication is the use of improper soap-water ratios.

While results are not absolutely conclusive, all information at hand appears to favor the use of non-combustible lubricant in starting air compressors as the most important factor in eliminating starting air system explosions. Continued effort in the development and use of such lubricants is necessary.

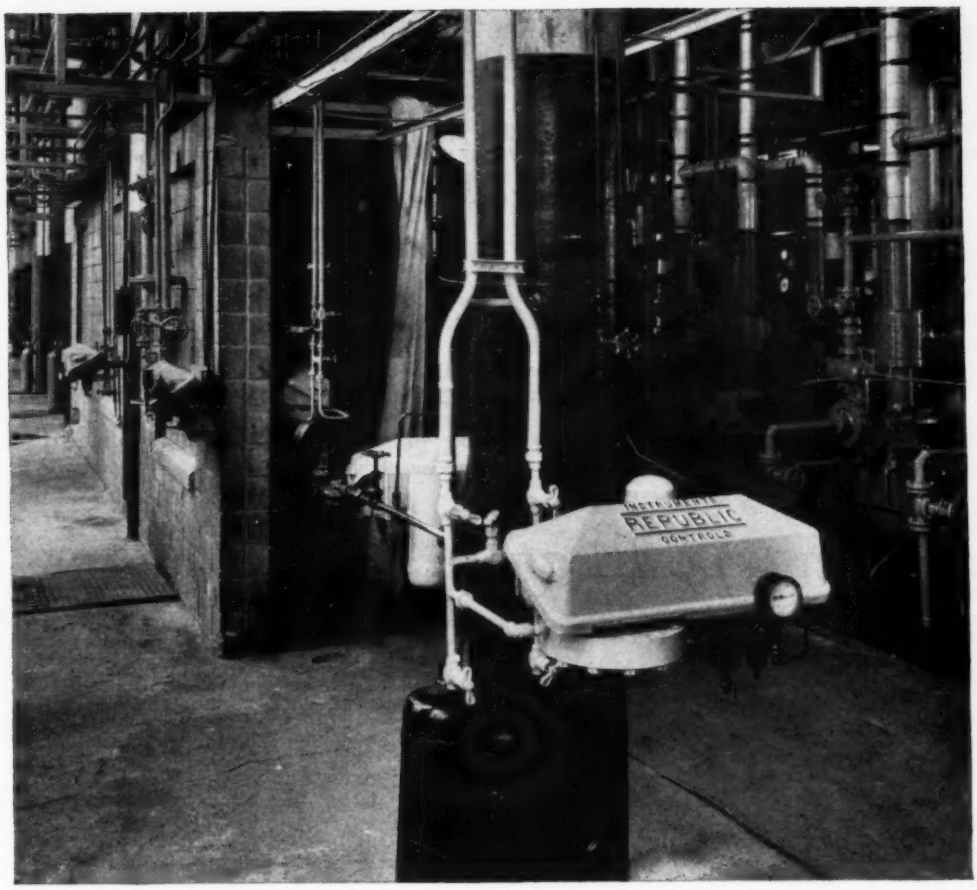
Little faith is placed in the use of rupture discs on air line headers. This attitude is possibly justified since the disruptive violence of the usual explosion is so great that the energy cannot be adequately dissipated by this means. Eleven companies do not have them. Of the four which do, one cites a case where a rupture disc possibly averted an explosion because it ruptured at a pressure higher than normally carried in the header and carbon was noted both on the pressure side of the disc and the top flange which held it in place. Another believes they always have prevented air line failures.—Paul Lindeman, Phillips Petroleum Co., Bartlesville, Okla.

Check Cooling Tower Performance Yearly

How are performance checks on cooling towers made and how often should they be made?

The plant operator will find it particularly beneficial to run performance checks at least once a year to determine if the cooling tower efficiency equals the showing made on the customary acceptance tests when the tower was new. A well designed and built tower should perform like new for several years.

The operator should be familiar with the design specifications furnished by the manufacturer. Also he should have a set of performance curves showing performance at other



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than design conditions, since it is unusual for all test conditions to exactly equal those specified by the builder.

Test procedure is described in detail in the ASME Power Code. Essentially it consists of obtaining inlet and outlet water temperatures, air wet and dry bulb temperatures at frequent intervals during constant weather conditions. Heat load and water circulation rate should be kept constant.

The inlet and outlet water temperatures are easily determined with mercury thermometers having an accuracy of ± 0.1° F. It has been found that the most constant atmospheric conditions prevail when the weather is clear, there are no clouds at low elevation and wind velocity is below 5 mph.

The wet bulb temperature is not so simply determined. It requires some practice to use a sling psychrometer, although it is the most convenient instrument. For most accurate results a special set-up with thermometer, wick and fan is recommended.

It is suggested that performance test conditions conform as closely as possible to design conditions. Since most cooling towers are designed for extreme summer weather it is preferable to run performance tests during this period.—Neal B. LauBach, Cooling Tower Division, Hudson Engineering Co., Houston.

Corrosion Problems in Plant Utility Equipment

What measures are suggested to prevent corrosion in steam and water piping, fittings, vessels and exchangers?

Boiler corrosion, whether the equipment is water- or fire-tube units, is dependent upon properly conditioned water. Deaeration of feedwater is paramount, because oxygen will cause rapid failure of boiler tubing, especially in water tube types, and generally in those tubes dropping out of the main steam drum. Where deaeration facilities are limited, the use of an antioxidant, such as sodium sulfite, is recommended.

Corrosion in condensate piping is common in varying degree to all installations and is proportional to the carbon dioxide present in the steam, evolving from the water by decomposition of bicarbonates. The quantity of raw water makeup, its composition and feedwater preparation are the contributing factors.

Feedwater treatment will reduce boiler and condensate piping corrosion, although some will be present in every system. Neutralizing agents may be helpful. A 60% solution of cyclohexylamine in water is one which is practical when a large percentage of condensate is returned, as it vaporizes in the boiler and condenses with the steam. Treatment of feedwater to prevent scaling and corrosion is a specialized subject beyond the scope of this discussion.

Return of steam condensate is economical where make-up water is scarce or treating costs high. Basically a dual return system is required. Clean condensate from preheaters and reboilers generally requires only deaeration. Dirty condensate from reciprocating pumps and still dehydrating trays must be separated from oil. A mixed condensate return, without oil separation and deaeration, will promote corrosion and boiler tube failures.

Preheaters, usually condensing steam on the shell side of tubular units with constant withdrawal of condensate, often are operated with conventional bucket-type steam traps. This is not desirable if faulty trap operation permits the condensate level to partially submerge the tubing. Corrosion of tubing and the interior shell wall will prevail from the carbonic acid, predominantly at steam and condensate interface.

If such failures are being experi-

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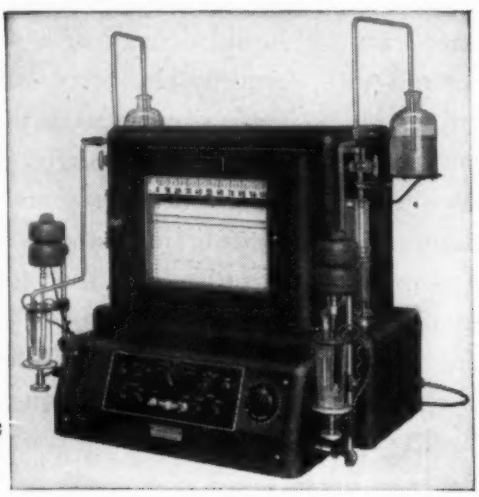

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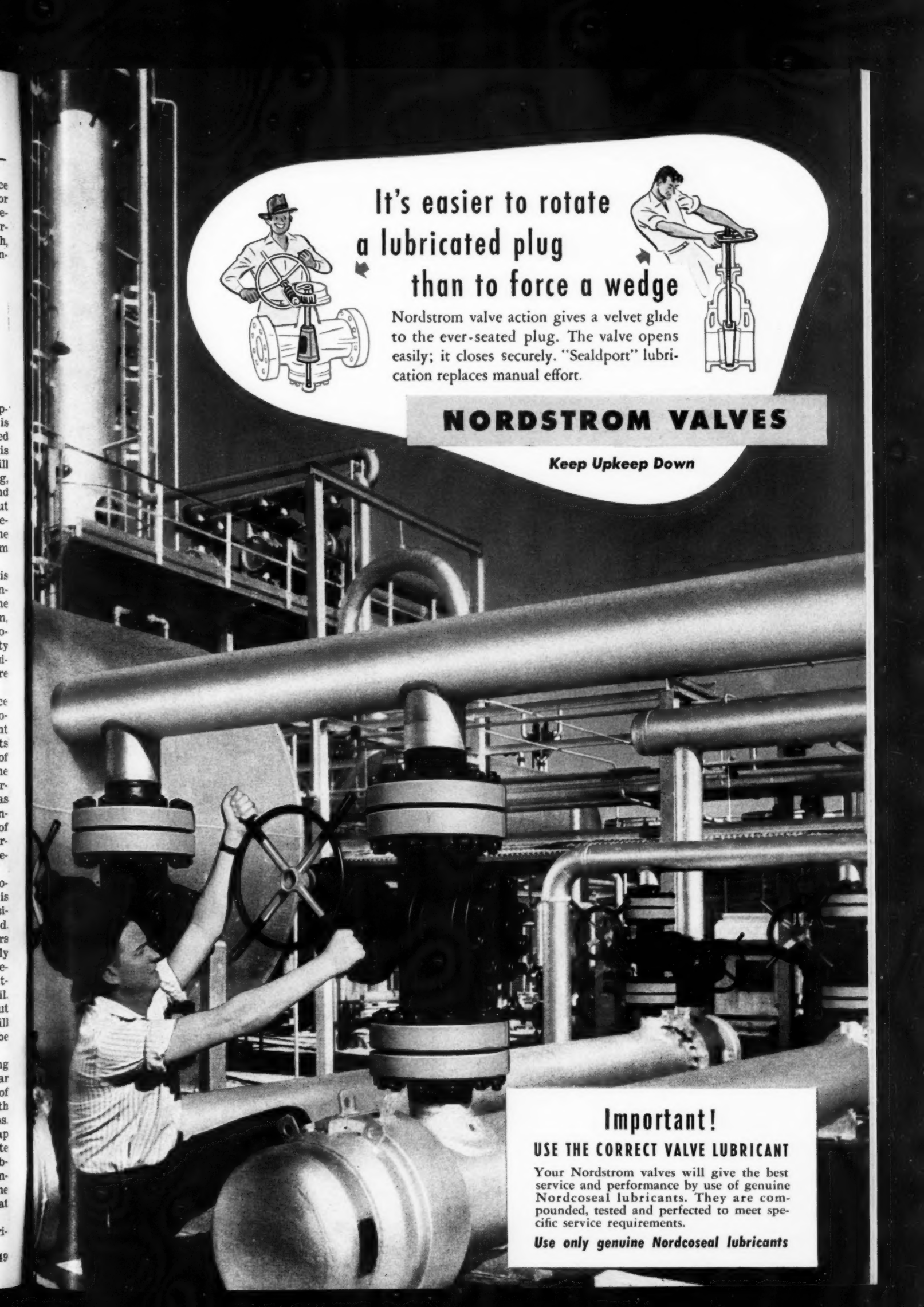
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Nordstrom valve action gives a velvet glide to the ever-seated plug. The valve opens easily; it closes securely. "Sealdport" lubrication replaces manual effort.
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USE THE CORRECT VALVE LUBRICANT
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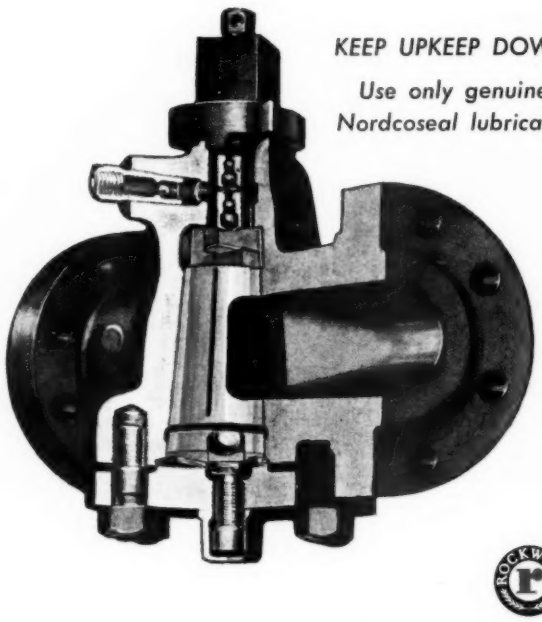

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enced, positive draining is recommended by utilizing a condensate accumulator or pot external to and located below the preheater. The accumulator should be equipped with liquid-level sight-gauge glasses and a liquid level float cage controlling flow through a motor valve in the condensate piping leaving the pot.

The pH value of cooling water is sometimes considered a guide to whether corrosion will or will not occur, the prevailing thought being that neutral or basic water is corrosion-free. This is not true for, with abundant oxygen invariably present, electrochemical attack will proceed at pH values ranging from 7 to 13 and the corrosion products may build up to restrict fluid flow

Water treatment for corrosion control will vary from plant to plant, but the use of a good algicide, controlled pH, injection of a protective film-forming agent where necessary and a suitable makeup water will help insure satisfactory operation.

Recommended control includes softening makeup water to 6-7 gr. per gal.; blowdown to keep alkalinity below 100 ppm. of free carbonate; treating with a sequestering agent such as sodium hexametaphosphate to maintain 2-3 ppm. of phosphate as a scale inhibitor; adding sulfuric acid as required to maintain desired pH, and algae control with liquid chlorine, copper sulfate stabilized with citric acid, Santobrite, or others.

Sodium dichromate often is used as corrosion inhibitor but if purge water may be drunk by stock or animals it should not be used because of its toxic effect. A thin layer of carbonate scale in cooling equipment is a good shielding agent against waterside corrosion. Sodium hexametaphosphate to prevent excessive scaling is popular but dosage must be carefully checked and controlled.—John H. Nashke, Gas Division, Humble Oil & Refining Co., Houston.

High Flash Oils Not Required For Compressor Lubrication

Should high flash oils be used for cylinder lubrication in air compressors to avoid an explosion hazard?

Operators defeat their purpose by specifying a high flash oil for air compressor operation, according to a widely advanced theory which holds this is not necessary even though the gas discharge temperature may be high. The flash point increases with increasing pressure and, even if the gas discharge temperature equals or exceeds the oil's flash at that pressure, auto-ignition would not result because the oil will not burn unless contacted with a flame.

High flash oils are necessarily paraffinic and tend to form a hard carbon residue when in contact with hot metal surfaces, such as valve discs, also cylinder walls and packing when the compressor is in poor mechanical condition. When carbon deposits on a valve disc it is likely to hold it open, thereby permitting discharge air to recycle and thus build up a high temperature. This can cause any carbon deposit to glow, resulting in fire and explosion should the glowing particles contact oil some place in the discharge line.

Naphthenic base oils have lower flash points than paraffinic oils, are characterized by a lesser degree of carbon deposits and the carbon is of a softer nature which does not leave a hard formation on the heated area with which it is in contact. These oils vaporize at the compressor cylinder operating temperature and much goes off as a vapor. The remaining carbon is soft and fluffy, therefore tending to travel along the air stream rather than build up detrimental deposits under the valve discs.—F. M. McNall and E. H. Flaherty, Clark Bros. Co., Inc., Olean, N. Y.

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As shown in the charts on the opposite page, Antioxidant No. 22 proved most effective in Stock A, Antioxidant No. 5 in Stock B. With gasoline C, in meeting this refiner's combined specifications of 240 minute induction period and 10 mg. copper dish gum, Antioxidant No. 6 proved most economical, although No. 5 gave the best induction period response. Wherever copper dish gum is of importance, Antioxidant No. 6 is usually the most economical. An added feature of Antioxidant No. 22 is its very low water solubility. Where water extraction by tank bottoms or in pipe lines, or extraction by caustic washing is a problem, Antioxidant No. 22 may be the answer. Whatever the Antioxidant treating problem—for maximum economy and maximum effectiveness—choose one of these 3 Du Pont Gasoline Antioxidants.

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DU PONT ANTIOXIDANT NO. 5—is a solution containing 50% Normal-butyl-para-aminophenol, 30% Anhydrous iso-propanol, and 20% Anhydrous methanol.

DU PONT ANTIOXIDANT NO. 6—is a solution containing 50% Iso-butyl-para-aminophenol, 30% Anhydrous iso-propanol, and 20% Anhydrous methanol.

DU PONT ANTIOXIDANT NO. 22—is a commercial grade of N:N' disecondary butyl-para-phenylene-diamine containing no solvents.

Concentration of Antioxidant* required to meet refiner's specification indicated below.

Gasoline C See Curve At Right	*240" Induction Period*	*10 mg. Copper Dish Gum*	*Combined Ind. Per. and Copper Dish Gum*
Antioxidant No. 5	0.0012%	0.0021%	0.0021%
Antioxidant No. 6	0.0014%	0.0009%	0.0014%
Antioxidant No. 22	0.0018%	0.0027%	0.0027%

**Active ingredient basis*

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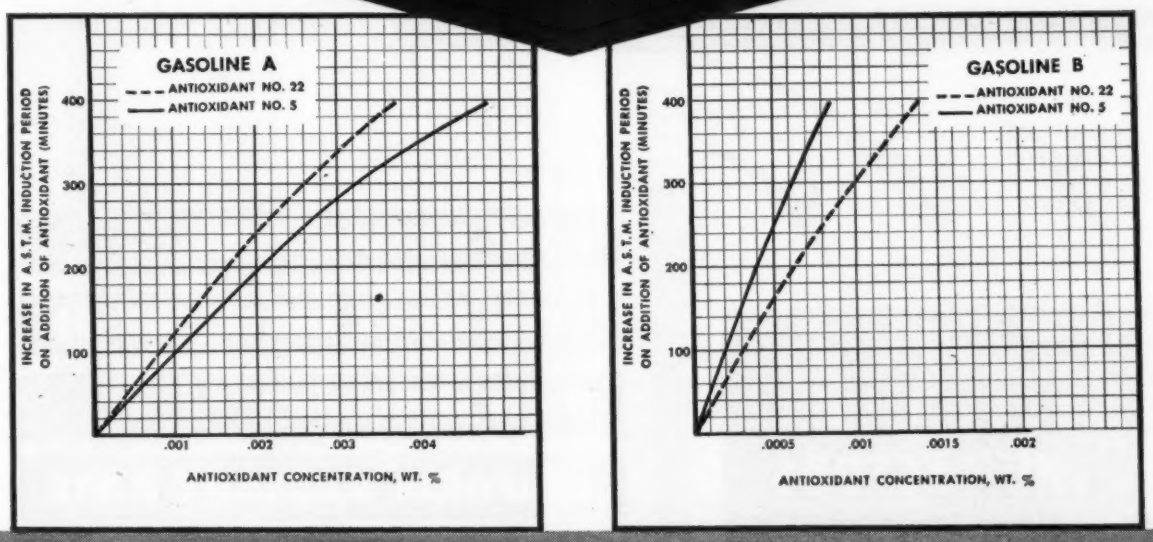
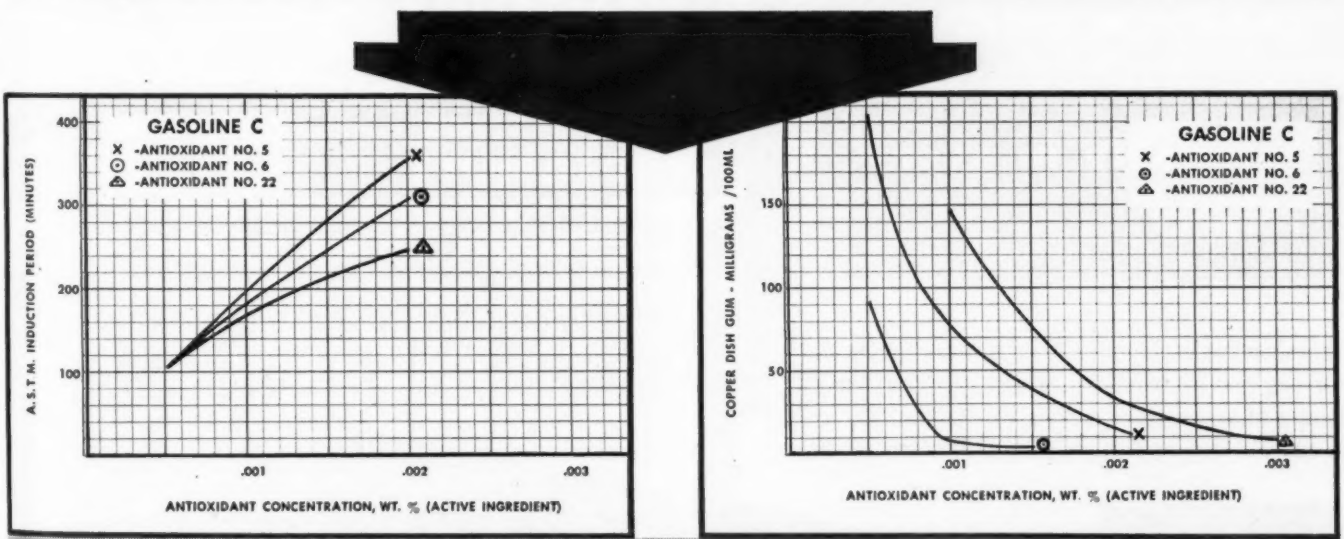


Induction period tests indicate that Antioxidant No. 22 will be most effective in Stock A . . . No. 5 in Stock B.



To meet refiner's combined specification of 240 minute induction period and 10 mg/100 ml copper dish gum content, No. 6 proved most economical.

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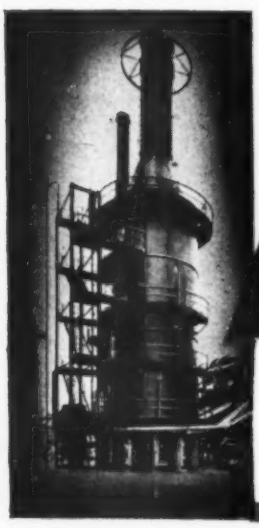

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REFINING TRENDS

Warm Days Back Up Distillate Stocks

CRUDE runs to stills in October were at a rate that indicated they will be held down through the last quarter of the year and that what increases in demand occur will be met by reducing stocks and, in the case of residual fuels, by a higher rate of imports. The disparity in the rate of crude runs to stills in October (Fig. 1), as compared with a year ago, was a little larger than the average for eight months of this year compared with last.

The Bureau of Mines now says that runs to stills may not exceed 5,500,000 b/d avg. for the last quarter, 200,000 bbls. less than its official forecast of three months ago.

Refinery production of distillate fuels (including kerosine), key product for the coming months, in October was under that of a year ago by about 8% (Fig. 4). The disparity was less, however, than for the first eight months of the year, when output of distillate fuels was 15% under that of the year preceding.

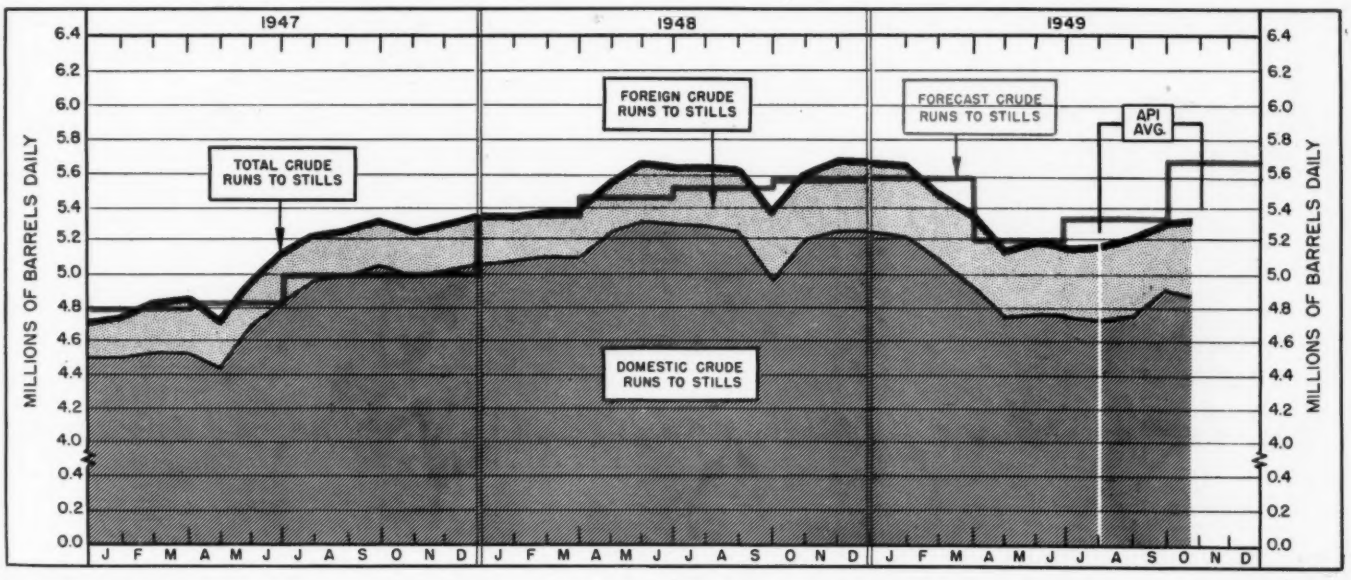
The rate of climb of distillate stocks the past few weeks (Fig. 5) reflects the unseasonally warm weather which has held down shipments into consuming centers. However, in terms of coming days' demand under normal temperatures, stocks are no greater factor in the supply-demand situation than a year ago. Even normal winter demand, in view of the rate at which oil burners are being installed, may require a considerably higher rate of runs to stills some weeks from now to meet heating oil demand.

Refiners' output of residual fuel oil is now at the lowest rate in three years (Fig. 6), the rate of production being not much higher than for distillate fuels. This reduced rate of output seems likely to continue, since the trend in imports of residual fuel is definitely up.

While gasoline output at refineries continued in October at a small rate of increase over the year before (Fig. 2), total motor fuel supply was still under demand. This is the first time in three years when demand has not dropped down to the level of refinery gasoline output at this period. As a result stocks continued to show a moderate decline.

Production of natural gasoline shows an upward trend in August (Fig. 8) and total output for eight months is 5.5% above that of the same period in 1948. The volume blended into motor fuel at refineries is nearly 14% higher than for eight months of 1948. (Fig. 10).

Fig. 1—Domestic and Foreign Crude Run to Stills



Yields on Crude Run to Stills

(Bureau of Mines Data)

	Gasoline	Kerosine	Dist. Fuels	Res. Fuels
August, 1949, %...	44.5	4.4	17.1	20.4
August, 1948, %...	41.0	5.2	18.4	22.1
August, 1947, %...	40.9	5.5	16.4	23.5

End-of-Month Inventories, Refinery Products, 1000 bbls

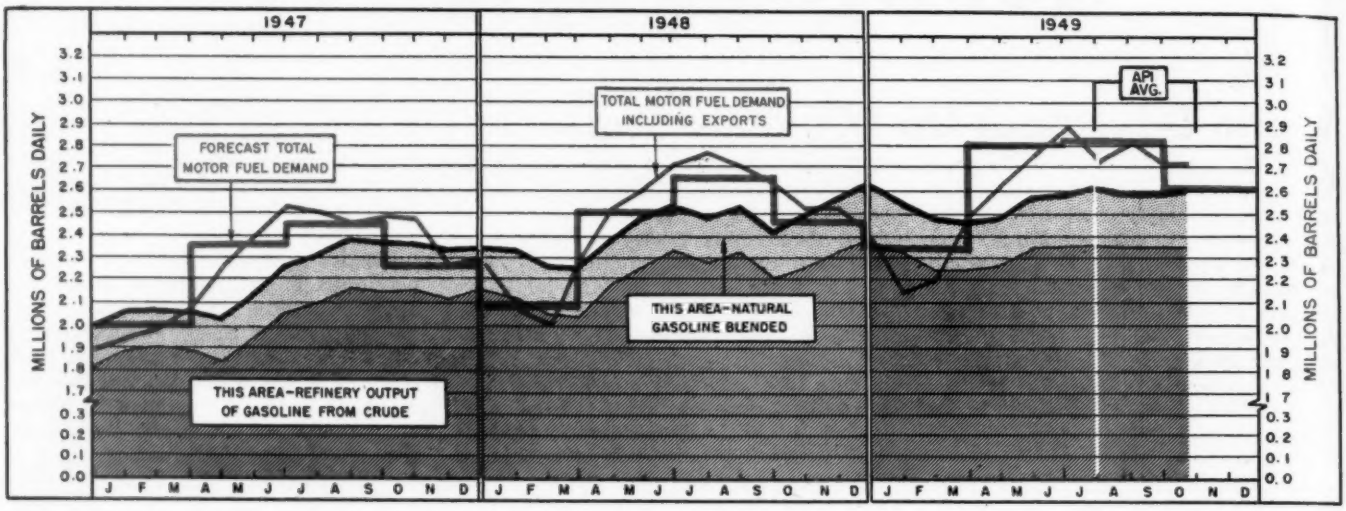
	Gasoline	Kerosine	Distillate	Residuals	Total
Sept. 30, 1949 (API data).....	103,850	27,115	83,200	67,981	282,146
Sept. 30, 1948 (B of M data)....	90,518	26,177	76,320	68,065	261,080
Sept. 30, 1947 (B of M data)....	84,360	22,276	59,764	57,772	224,172

U. S. Refinery Operations, bbls

	Crude Runs to Stills			Motor Fuel Supply			Distillate Production			Residuals		
	Domestic	Foreign	Total	Gasoline from Crude	Natural Blended, Used Direct	Total	Kerosine	Distillate	Total	Refinery Prod.	Imports	Totals
Oct., 1949, b/d avg.*.....	4,883,000	467,200	5,350,000	2,360,000	310,000	2,670,000	288,000	988,000	1,276,000	1,075,000	250,000**	1,325,000
Oct., 1948, b/d avg.	5,201,000	393,000	5,672,000	2,275,000	290,000	2,565,000	311,700	1,069,100	1,380,800	1,268,100	100,200	1,368,300
Change in 1949, b/d	—318,000	+74,200	—322,000	+85,000	+20,000	+105,000	—23,700	—81,100	—104,800	—193,000	+149,800	—43,300
	(6.1%)	(18.6%)	(5.7%)	(3.7%)	(6.9%)	(4.1%)	(7.6%)	(7.6%)	(7.6%)	(15.2%)	(149.5%)	(3.2%)
8 Mos., 1949, 1000 bbls.	1,186,985	99,578	1,286,963	564,267	70,781	635,000	64,692	217,588	282,280	283,475	41,922	325,397
8 Mos., 1948, 1000 bbls.	1,273,120	75,340	1,348,460	538,719	67,478	606,197	81,203	251,831	333,034	313,744	36,322	350,066
Change in 1949, 1000 bbls.	—86,225	+24,238	—61,497	+25,548	+3,303	+29,851	—16,511	—34,243	—50,754	—30,269	+5,600	—24,669
	(6.7%)	(32.2%)	(4.6%)	(4.7%)	(4.9%)	(4.9%)	(20.3%)	(13.6%)	(15.2%)	(9.6%)	(15.4%)	(7.0%)

* Through Oct. 22, 1949, only. ** Estimated.

Fig. 2—Gasoline Supply, Demand and Forecast


1947
1948
1949
MILLIONS OF BARRELS DAILY
FORECAST TOTAL MOTOR FUEL DEMAND
TOTAL MOTOR FUEL DEMAND INCLUDING EXPORTS
API AVG.
THIS AREA-NATURAL GASOLINE BLENDED
THIS AREA-REFINERY OUTPUT OF GASOLINE FROM CRUDE
J F M A M J J A S O N D

The motor fuel demand line and the forecast demand line include, in addition to refinery gasoline and natural gasoline blended at refineries, a varying volume of natural gasoline used direct as motor fuel. This volume averages around 70,000 b/d.

Fig. 3—Gasoline Stocks

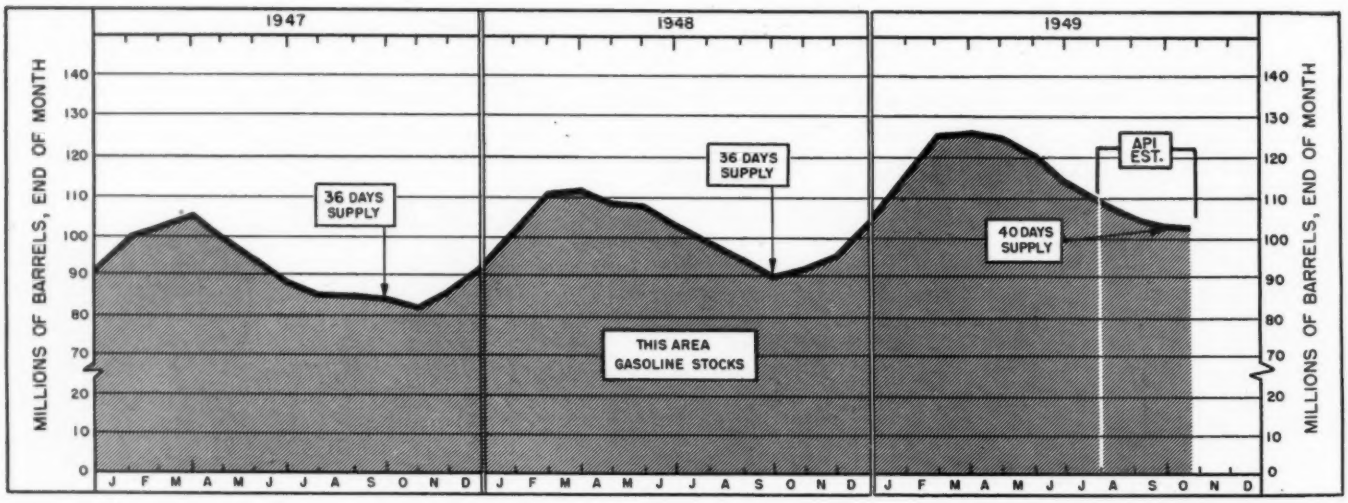


Fig. 4—Kerosine and Distillate Fuel Oil Supply, Demand and Forecast

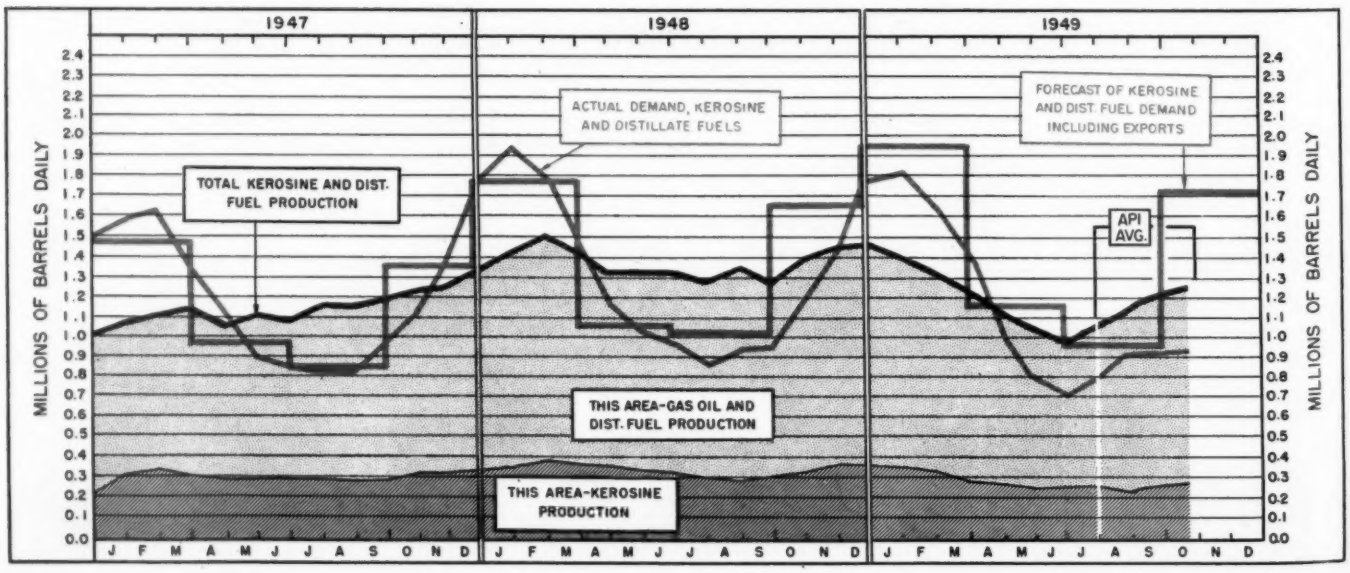
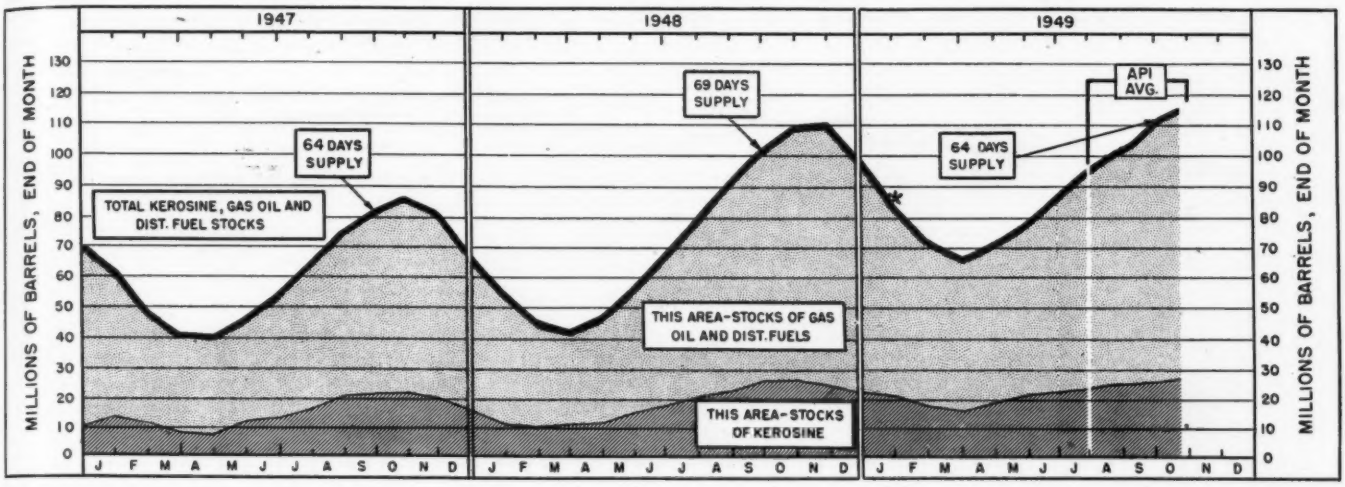

1947
1948
1949
MILLIONS OF BARRELS DAILY
TOTAL KEROSINE AND DIST. FUEL PRODUCTION
ACTUAL DEMAND, KEROSINE AND DISTILLATE FUELS
FORECAST OF KEROSINE AND DIST. FUEL DEMAND INCLUDING EXPORTS
API AVG.
THIS AREA-GAS OIL AND DIST. FUEL PRODUCTION
THIS AREA-KEROSINE PRODUCTION
J F M A M J J A S O N D

Fig. 5—Kerosine and Distillate Fuel Oil Stocks


1947
1948
1949
MILLIONS OF BARRELS, END OF MONTH
64 DAYS SUPPLY
TOTAL KEROSINE, GAS OIL AND DIST. FUEL STOCKS
69 DAYS SUPPLY
THIS AREA-STOCKS OF GAS OIL AND DIST. FUELS
THIS AREA-STOCKS OF KEROSINE
API AVG.
64 DAYS SUPPLY
J F M A M J J A S O N D

* About 5,000,000 bbls. of the drop in kerosine and distillate stocks shown in January, 1949, is due to a difference in reporting adopted in California, where cracking stocks were dropped from this classification.

Fig. 6—Residual Fuel Oil Supply, Demand and Forecast

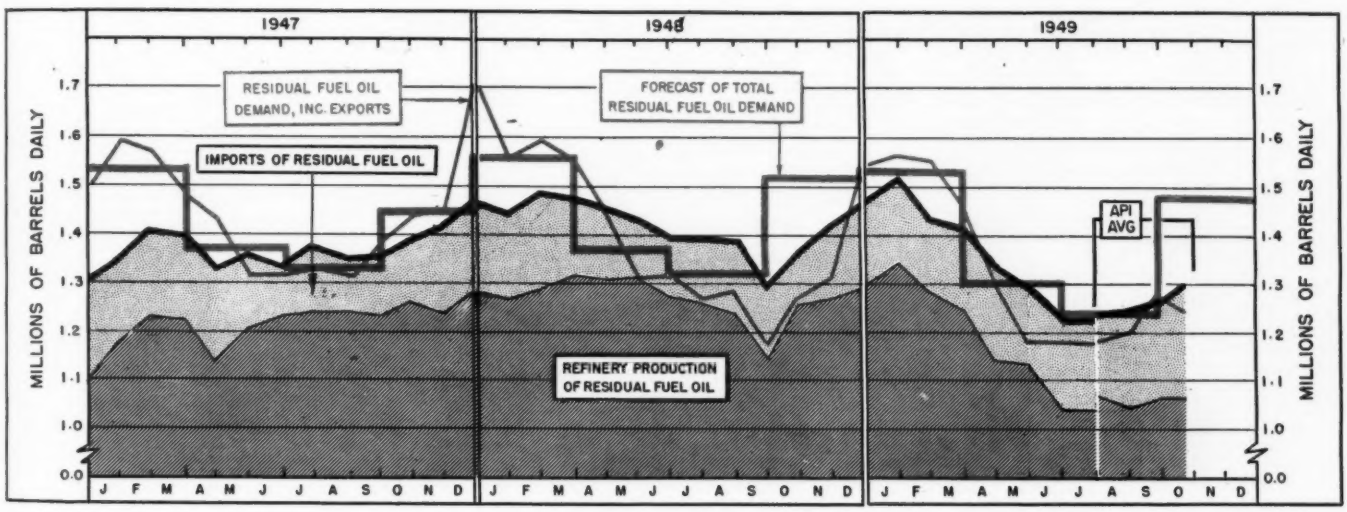
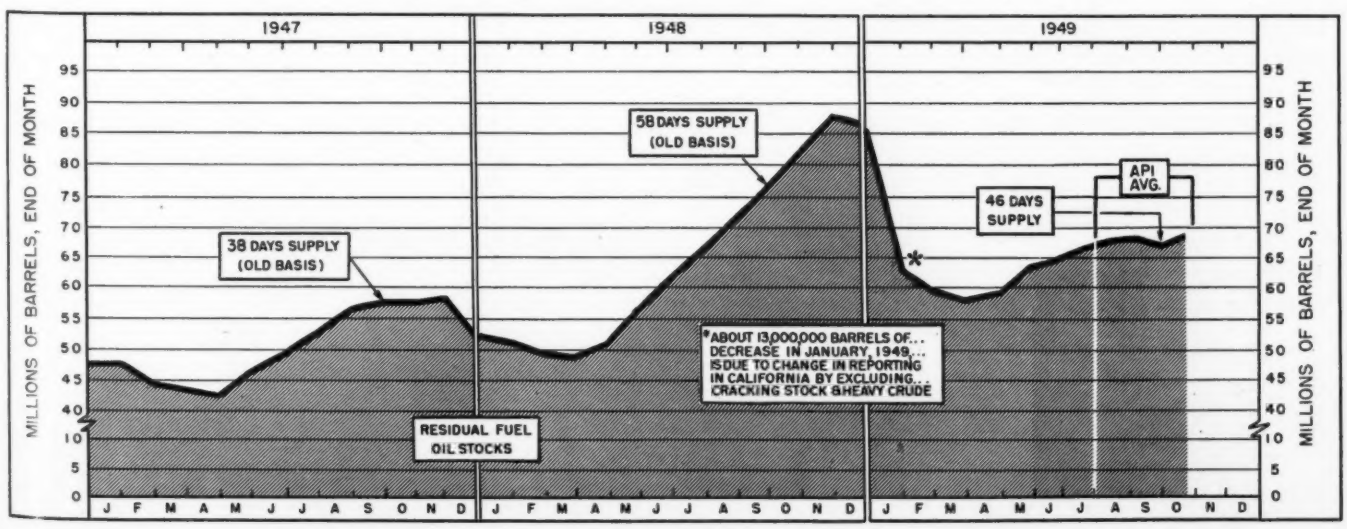

1947
1948
1949
MILLIONS OF BARRELS DAILY
RESIDUAL FUEL OIL DEMAND, INC. EXPORTS
IMPORTS OF RESIDUAL FUEL OIL
FORECAST OF TOTAL RESIDUAL FUEL OIL DEMAND
REFINERY PRODUCTION OF RESIDUAL FUEL OIL
API AVG
J F M A M J J A S O N D

Fig. 7—Residual Fuel Oil Stocks


1947
1948
1949
MILLIONS OF BARRELS, END OF MONTH
38 DAYS SUPPLY (OLD BASIS)
58 DAYS SUPPLY (OLD BASIS)
46 DAYS SUPPLY
API AVG.
RESIDUAL FUEL OIL STOCKS
*ABOUT 13,000,000 BARRELS OF... DECREASE IN JANUARY, 1949... IS DUE TO CHANGE IN REPORTING IN CALIFORNIA BY EXCLUDING... CRACKING STOCK & HEAVY CRUDE
J F M A M J J A S O N D

* Residual fuel oil stocks July 31, 1949, (API data) new basis, 67,183,000 bbls. Stocks July 31, 1948, old basis, 66,262.000 bbls: July 31, 1947, 52,808,000 bbls.

Fig. 8—Production of Natural Gasoline and Production Forecast

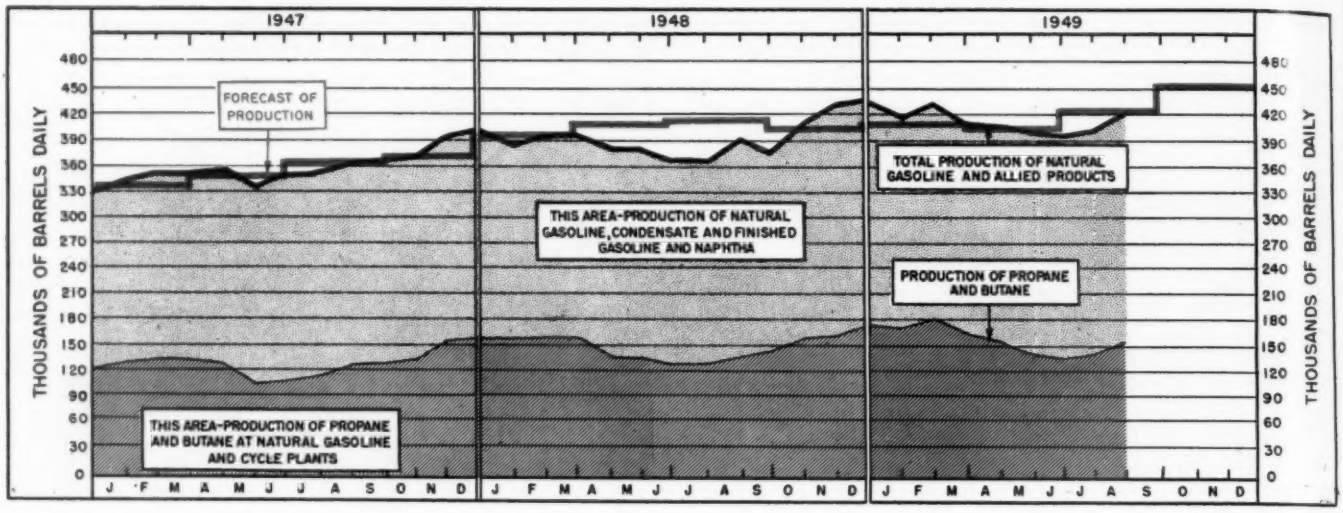
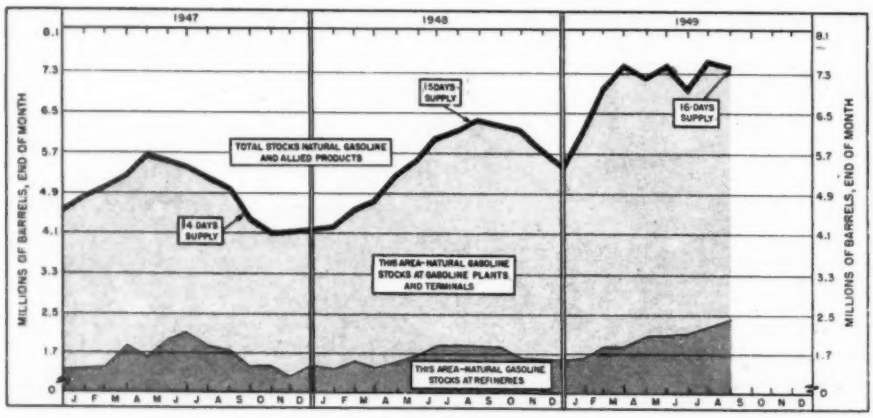

1947
1948
1949
THOUSANDS OF BARRELS DAILY
FORECAST OF PRODUCTION
TOTAL PRODUCTION OF NATURAL GASOLINE AND ALLIED PRODUCTS
THIS AREA-PRODUCTION OF NATURAL GASOLINE, CONDENSATE AND FINISHED GASOLINE AND NAPHTHA
PRODUCTION OF PROPANE AND BUTANE
THIS AREA-PRODUCTION OF PROPANE AND BUTANE AT NATURAL GASOLINE AND CYCLE PLANTS
J F M A M J J A S O N D

Fig. 9—Stocks of Natural Gasoline

(Days supply figured in terms of current demand)

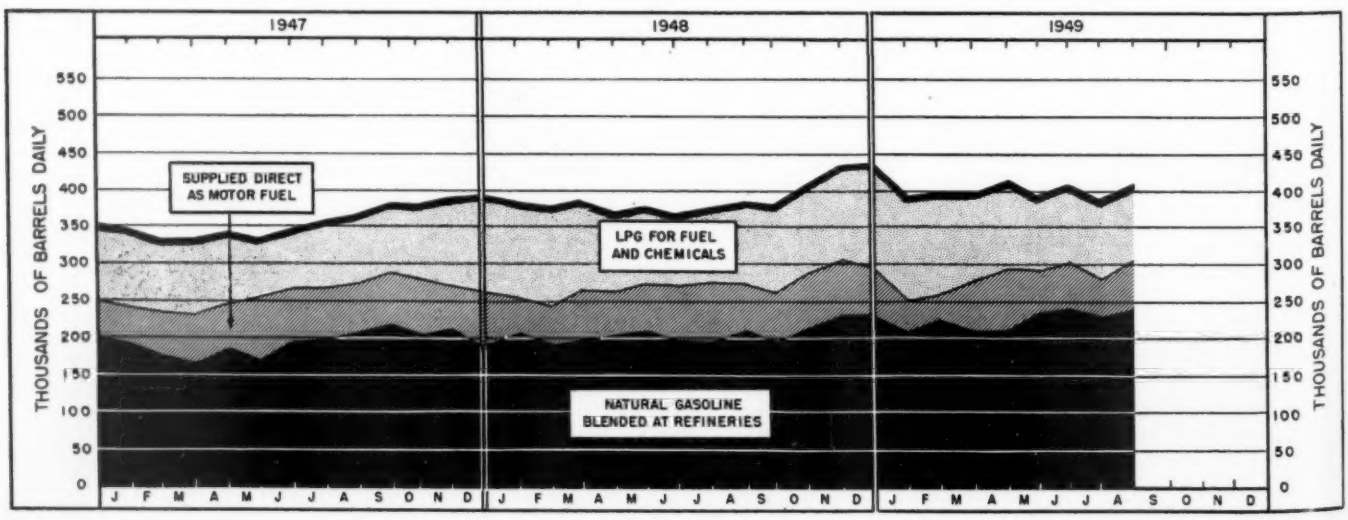

1947
1948
1949
MILLIONS OF BARRELS, END OF MONTH
15 DAYS SUPPLY
TOTAL STOCKS NATURAL GASOLINE AND ALLIED PRODUCTS
14 DAYS SUPPLY
THIS AREA-NATURAL GASOLINE STOCKS AT GASOLINE PLANTS AND TERMINALS
THIS AREA-NATURAL GASOLINE STOCKS AT REFINERIES
J F M A M J J A S O N D

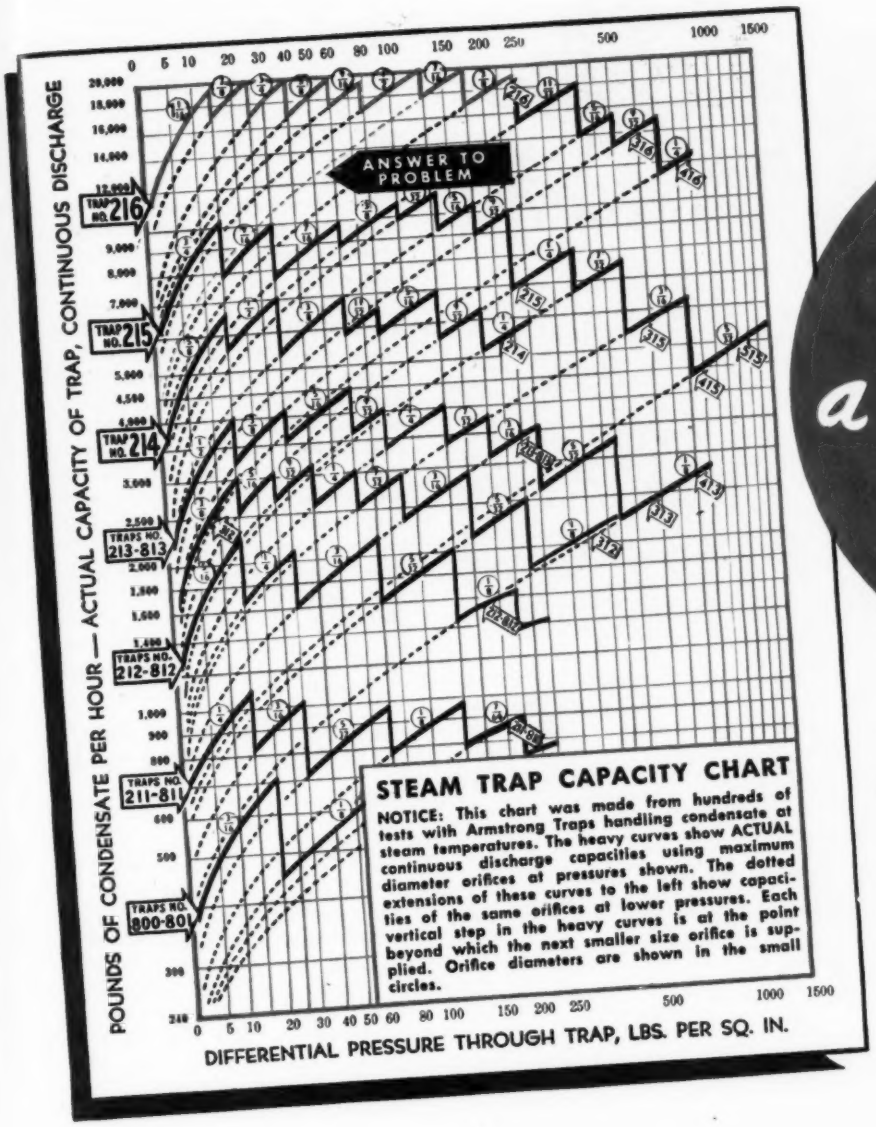
Natural Gasoline Statistics

(Bureau of Mines data)

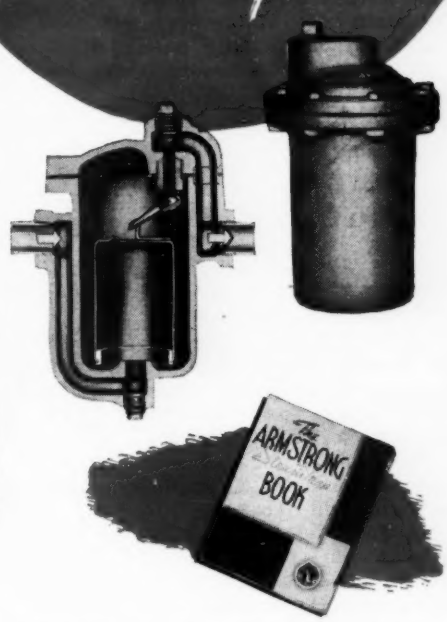
	Production, b/d avg.		
	Propane & Butane	Heavier Naturals	Total
August, 1949	152,800	268,000	421,000
August, 1948	134,800	256,200	391,000
Change in 1949	+18,000	+11,800	+30,000
	(13.3%)	(4.6%)	(7.7%)
	Total Production, 1000 bbls.		
8 Mos., 1949	37,430	62,663	100,090
8 Mos., 1948	34,384	60,440	94,824
Change in 1949	+3,046	+2,223	+5,266
	(8.8%)	(3.7%)	(5.5%)
	Principal Uses, b/d avg.		
	Blended at Refineries	Supplied Direct as Motor Fuel	LPG for Fuel and Chemicals
August, 1949	236,000	68,000	118,000
August, 1948	211,000	66,300	105,000
Change in 1949	+25,000	+1,700	+13,000
	(11.8%)	(2.6%)	(12.4%)
	Total Demand, 1000 bbls.		
August, 1949	54,912	14,052	27,783
August, 1948	48,562	15,658	26,375
Change in 1949	+6,350	−1,606	+1,408
	(13.7%)	(10.3%)	(5.3%)
	Stocks, End of Month, 1000 bbls.		
	Refineries	Gasoline Plants	Total
August, 1949	2,478	4,913	7,391
August, 1948	1,831	4,477	6,308
Change in 1949	+647	+436	+1,083
	(35.0%)	(9.7%)	(17.1%)

Fig. 10—Principal Demand for Natural Gasoline


1947
1948
1949
THOUSANDS OF BARRELS DAILY
SUPPLIED DIRECT AS MOTOR FUEL
LPG FOR FUEL AND CHEMICALS
NATURAL GASOLINE BLENDED AT REFINERIES
J F M A M J J A S O N D


ANSWER TO PROBLEM
TRAP NO. 216
TRAP NO. 215
TRAP NO. 214
TRAPS NO. 213-813
TRAPS NO. 212-812
TRAPS NO. 211-811
TRAPS NO. 800-80
POUNDS OF CONDENSATE PER HOUR — ACTUAL CAPACITY OF TRAP, CONTINUOUS DISCHARGE
DIFFERENTIAL PRESSURE THROUGH TRAP, LBS. PER SQ. IN.
STEAM TRAP CAPACITY CHART
NOTICE: This chart was made from hundreds of tests with Armstrong Traps handling condensate at steam temperatures. The heavy curves show ACTUAL continuous discharge capacities using maximum diameter orifices at pressures shown. The dotted extensions of these curves to the left show capacities of the same orifices at lower pressures. Each vertical step in the heavy curves is at the point beyond which the next smaller size orifice is supplied. Orifice diameters are shown in the small circles.

HOW TO SOLVE a Steam Trap PROBLEM:



BECAUSE good trapping starts with selection of the right trap for the job, Armstrong has provided all the data necessary for correct trap selection in the Armstrong Steam Trap Book. The Capacity Chart reproduced here is taken from this handy reference work. By means of this chart, any engineer can select the correct traps for his requirements. Here is a typical problem showing how the chart is used:

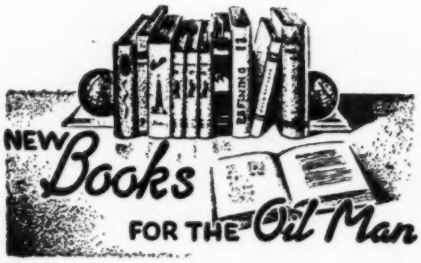
Given: An evaporator condensing 6000 lbs/hr at 50 psi when the steam is first turned on, but condensing only 1000 lbs/hr at 150 psi at the end of the process. Safety factor of 2 to 1 required at the *minimum* pressure differential.

Solution: Referring to the chart, the No. 216 Armstrong Trap with 7/16" orifice for 150 psi pressure has a capacity of 12,000 lbs/hr at 50 psi. This provides for the 2 to 1 safety factor and is, therefore, the correct trap for the job.

The Armstrong Steam Trap Book provides recommended safety factors for different services and handy tables to help you calculate condensing rates. Other useful data included are: hook-up diagrams; do's and don't's; trouble-shooting tips; prices and specifications. You're welcome to a copy. **ARMSTRONG MACHINE WORKS, 826 Maple Street, Three Rivers, Michigan.**

ARMSTRONG *Inverted Bucket* **STEAM TRAPS**

For fuel savings, low maintenance, automatic air removal ***SPECIFY ARMSTRONG!***



Lange's Chemistry Handbook Revised in New 7th Edition

Handbook of Chemistry, 7th Edition; compiled and edited by Norbert A. Lange: 5⅝ x 7¾ in., 1934 pages, fabricoid binding, indexed, $7.00. Handbook Publishers, Inc., Sandusky, Ohio.

Once again Dr. Lange has revised, extended, and brought up to date his widely-used *Handbook of Chemistry*, in this newly published 7th Edition.

One notable change has been the omission for the first time of a major portion of the mathematical tables, to allow space for data more directly applicable to the field of chemistry. Whereas the tables occupied about 270 pages in the previous edition, they have now been reduced to 66. The main body of the book has been increased substantially with the following new tables among those not in the previous edition:

Formulas for calculating mineral-free Btu. and fixed carbon, ASTM classification of coals by rank, density of fuming sulfuric acid solutions, partial pressures of aqueous ammonia solutions, Kopp's rule for calculating specific heat, logarithms of equilibrium constants, viscosity of aqueous ethyl alcohol solutions, etc.

In addition, the following tables are among those which have been extended or completely rewritten: the gas constant; periodic chart of the elements; table of isotopes, plastics and synthetic rubbers; corrosion and heat resistant alloys; commonly used ceramic materials, etc.

Dr. Lange, who has compiled this book since the first edition in 1934, is a lecturer in chemistry at Cleveland College of Western Reserve University, and a member of the American Chemical Society and the American Institute of Chemists.

He was again assisted by Gordon M. Forker of the General Electric Co., Cleveland.

Radioactive Tracer Manual Said to be Pioneer in Field

Radioactive Tracer Techniques, by Schweitzer and Whitney; 5½ x 8½ in., vi + 241 pages, stiff cloth binding, illustrated, indexed, $3.25. D. Van Nostrand Co., Inc., New York.

Designed as a guide for laboratory work and instruction in the use of radioactive tracers, this new book is a pioneer in its field. The rapid progress in this field has begun to show its effects in many industries, as witness the recent news accounts of the utilization of radioactive tracers in the petroleum industry. For example, tracers have been used to watch the progress of reactions in refinery process units and also in the study of the effects of petroleum products in automotive engines.

In view of the comparatively wide distribution of radioactive materials, little information has as yet been made available concerning their use as tracers. This book should do much to fill that gap in knowledge, both for the industrial laboratory and the university research center.

Following the presentation of fundamentals in the first four chapters, the book goes on to present experimental work in four major classifications — basic, chemical, physical, and biological. A final chapter discusses special preparations. An appendix of general information also is provided.

Author George K. Schweitzer is assistant professor of chemistry, the University of Tennessee, and Ira B. Whitney is chief supervisor, Radio Chemical Process Development, Oak Ridge National Laboratories.

Britisher Writes Survey on Petroleum Chemicals Industry

The Petroleum Chemicals Industry, by Richard Frank Goldstein: 6¼ x 10 in., xiii + 449 pages, cloth-covered board binding, illustrated, indexed, £3 3s. E. & F. Spon Ltd., 57, Haymarket, S. W. 1, London, England.

In this survey of the *Petroleum Chemicals Industry*, the author has attempted "to give a clear and reasonably comprehensive picture of the state of the art on each subject dealt with, special emphasis being laid on developments during the last ten years (prior to 1948)." As pointed out in the preface, the chemistry of petroleum derivatives up to 1937 has been fully documented by Carleton Ellis in his famous two volumes, *The Chemistry of Petroleum Derivatives*, but Goldstein has wisely not attempted the Ellis all-inclusive approach in compiling the present book. What he has done is to collect the basic chemical theories and details of manufacturing processes on the products considered, in a fashion particularly readable by chemists and chemical engineers who are interested in gaining a sound background in this growing field.

In content, the book's 20 chapters range from "the source of petroleum hydrocarbons" to "chemical by-products from petroleum refining" (the latter discussion being so sketchy as to be practically worthless), with intermediate chapters on such subjects as "synthesis and reactions of carbon monoxide-hydrogen mixtures"; "oxidation of paraffins"; nitration; olefin manufacture, hydration, oxidation, and other reactions; various types of hydrocarbons; ketones; nitriles and amines; etc. A particularly noteworthy feature is the inclusion of many flowsheets of reactions and derivatives.

This book should be of much more value in Great Britain than here, however, since the data compiled are relatively easily acquired in this country by the interested user—who usually will require more information than contained in the sketchy accounts to which space requirements have limited the author. While competing processes are mentioned and qualitative economic statements are made, many of the book's statistics are already out of date. Nevertheless, this book will be of considerable value to many readers in this country, since it is much more up to date than Ellis' works and since its very shortness (comparatively) makes for far more rapid comprehension.

—*B. H. Weil*

Volume on Organic Analysis By Infrared Method Published

Infrared Determination of Organic Structures, by Randall, Fowler, Fuson, and Dangl; 8½ x 11, vi + 239 pages, stiff cloth binding, illustrated, indexed, $10.00. D. Van Nostrand Co., Inc., New York.

Infrared spectroscopy is receiving increased attention in the petroleum industry, not only as a technique for the research man but also as a tool for routine process control and as a potential process control instrument. Little data has been published as yet concerning this type of work. Methods of analysis by infrared spectroscopy are largely empirical, hence the certainty of the investigator in its use is limited largely to his experience and background. *Infrared Determination of Organic Structures* will do much in the way of supplying that background.

After several introductory chapters devoted to the technique of analysis, the major portion of the book is given over to a valuable series of about 375 halftone illustrations of the actual records of a great variety of compounds. For ease of use, these substances have been grouped in distinct classifications: acids, esters, salts, aldehydes, alcohols, sulfides, ethers, amines, and many others.

The work is largely the result of government sponsored research in 1942-45 to determine the structure of penicillin and, if possible, synthesize it. It was necessary to study the spectra of many compounds, not all directly related to the penicillin molecule in structure, but usually of the common family of aliphatic or phenyl substituted aliphatic compounds. No claim is made, therefore, to a complete treatment of the present status of infrared spectroscopy. However, the book should be of great value to anyone interested in this

Book Reviews

field and the extent to which it can be helpful in the chemistry of petroleum, rubber, plastics, and the like.

H. M. Randall is Emeritus Professor and former chairman of the department of physics, University of Michigan; R. G. Fowler is associate professor of physics, University of Oklahoma; Nelson Fuson, department of chemistry, Johns Hopkins University; and J. R. Dangl, a research physicist. Although predominantly physicists, the authors' approach has been patterned to the problems of the organic chemist.

Society Publications

API Tentative Standard 600 *on Flanged and Welding End Plug and Valve Gates,* supplanting former *API Standards* 600-*A* and 600-*B*. Order copies at $1.50 each from J. A. McNally, American Petroleum Institute, 50 West 50th St., New York 20, N. Y.

Government Publications

Revised Bibliography of Bureau of Mines Investigations on the Production of Liquid Fuels from Oil Shale, Coal, Lignite, and Natural Gas (to 1949): Information Circular 7534, by Norma Golumbic, Hazel C. Anderson, and Robert C. Grass, Dept. of Interior, Bureau of Mines, 8 x 10½ in., 53 pages, heavy paper binding, Sept., 1949. Order free copy direct from Bureau of Mines, Publications Distribution Section, 4800 Forbes St., Pittsburgh 13, Penna.

National Motor-Gasoline Survey, Winter 1948-49, by O. C. Blade: 8 x 10½ in., 33 pages, paper binding, Report of Investigations 4567. Published by the Bureau of Mines, Dept. of the Interior. Order direct from the BofM publication Office, 4800 Forbes St., Pittsburgh 13, Pa.

Estimated Plant and Operating Costs for Producing Gasoline by Coal Hydrogenation, by L. W. Hirst, J. A. Markovits, L. C. Skinner, R. W. Dougherty, and E. E. Donath: 8 x 10½ in., 83 pages, paper binding, Report of Investigations 4564. Published by the Bureau of Mines, Dept. of the Interior. Order direct from the Mines Bureau Publication Office, 4800 Forbes St., Pittsburgh 13, Pa.

Unless otherwise indicated, copies of all books reviewed here may be ordered from the Reader's Service Department, Petroleum Processing, 1213 West Third Street, Cleveland 13, Ohio, for the price listed, postpaid. Ohio purchasers please add 3% tax. NOTE: publisher's prices are subject to change without notice.

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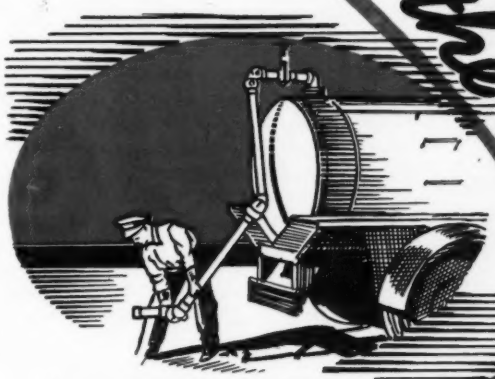

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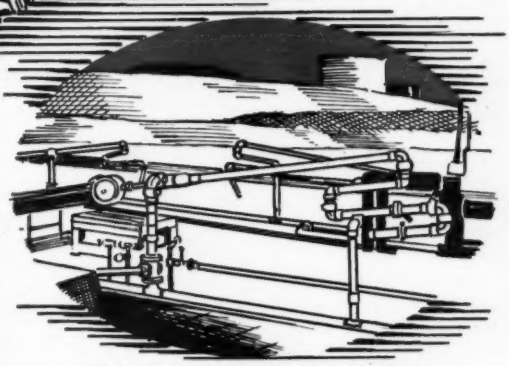

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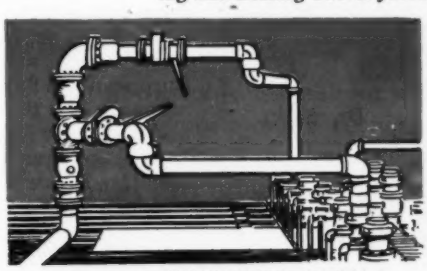

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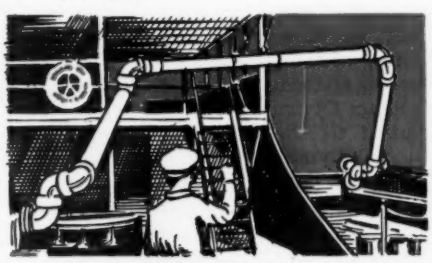

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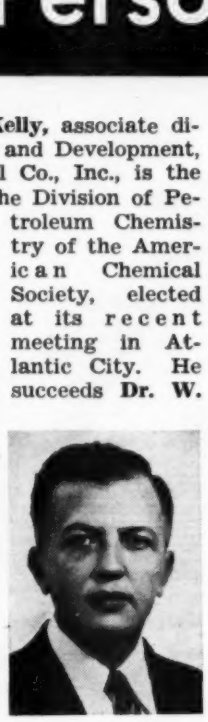
BALL-BEARING SWIVEL JOINTS FOR ALL PURPOSES

Personals

Dr. Arlie A. O'Kelly, associate director of Research and Development, Socony-Vacuum Oil Co., Inc., is the new chairman of the Division of Petroleum Chemistry of the American Chemical Society, elected at its recent meeting in Atlantic City. He succeeds **Dr. W. E. Kuhn,** manager, Technical and Research Division, The Texas Co.

Dr. O'Kelly



Dr. Shoemaker

Dr. Bernard H. Shoemaker, assistant director of research for Standard Oil Co. (Indiana), was chosen chairman-elect of the Division of Petroleum Chemistry.

Dr. O'Kelly graduated from University of Arkansas in 1926 and received his PhD in chemistry at the University of Colorado. He went with Socony-Vacuum at Paulsboro, N. J., in 1935 and in 1944 was named supervising chemist in charge of chemical research. He was made associate director of research in 1947. Dr. Shoemaker graduated from Hope College in 1926 and received his PhD in chemistry at Ohio State University. He has been with the Standard of Indiana research staff since 1930, being made assistant director of research in 1946.

C. G. Kirkbride, Houdry Process Corp., Philadelphia, was reelected secretary-treasurer of the ACS Petroleum Division. The following were named to the executive committee: **A. L. Lyman,** California Research Corp.; **H. M. Smith,** U.S. Bureau of Mines; **Louis Schmerling,** Universal Oil Products Co.; **W. A. McMillan,** The Texas Co.; **C. L. Brown,** Standard Oil Development Co.; **S. W. Ferris,** Sun Oil Co.

* * *

R. Rea Jackson, general manager of the Socony-Vacuum refinery at Paulsboro, N. J., is a representative on a 10-member committee for coordinating and activating the economic future of the Greater Philadelphia-South Jersey area. Nine other counties are represented on the committee, members of which were appointed by the governors of Pennsylvania and New Jersey. Mr. Jackson started with Magnolia Petroleum as a chemist in 1923 and became general manager at Paulsboro in 1947.

* * *

M. J. Rathbone, president of Esso Standard Oil Co., has been elected a director of Standard Oil Co. (N.J.). He has had 28 years experience with the parent company and its affiliates.

After service in World War I he received a degree in chemical engineering from Lehigh University in 1921, and soon after started work in the drafting department of Standard Oil Co. of Louisiana, at Baton Rouge. He became assistant general manager of the manufacturing department of that company in 1933, vice president and general manager in 1935, and president in 1936. He went to New York as Esso's president in 1944.

* * *

Stanley C. Hope is president of Esso Standard Oil Co., succeeding **M. J. Rathbone,** who joins the parent company, Standard Oil Co. (N.J.) as a director. Mr. Hope was formerly executive vice president and director of Esso.

Mr. Hope

Mr. Hope started work with the Gilbert & Barker Mfg. Co., and subsequently held positions as New York and European sales manager of this manufacturer of oil burners, air conditioning and gasoline pumping equipment. He was made vice-president of Gilbert & Barker in 1927 and president in 1932. In 1946 he became president of Stanco Inc., specialty products affiliate of S.O.N.J. He was elected vice president of Esso Standard in 1948.

Dr. Burks

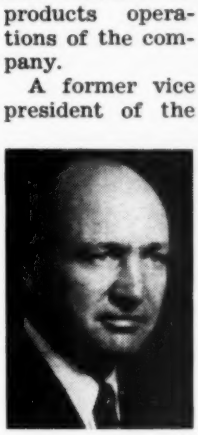
Dr. H. G. Burks, Jr., has been made executive vice president of Esso Standard Oil Co. He was former vice president and director. He joined the company as a development engineer in 1924, and rose through various manufacturing positions to director in 1943. He was made general manager of the company's East Coast refineries in 1946 and general manager of manufacturing in 1948. He was elected vice president in January, 1949.

* * *

M. W. Boyer, vice president and general manager of manufacturing, Esso Standard Oil Co., has been made vice president and contact director for manufacturing, supply and transportation, and chemical products operations of the company.

Mr. Boyer

A former vice president of the company in the Louisiana Division and general manager of its Baton Rouge refinery, he joined the company in 1927 where he was an assistant and associate in the chemistry laboratory. He is a graduate of M.I.T. and also received a master's degree in chemical engineering there. He was elected vice president and director of Esso Standard in 1945.



Mr. Naden

William Naden, a director and manager of employe relations in Esso Standard, succeeds Mr. Boyer as director and general manager of manufacturing. A graduate of Lowell Textile Institute in chemistry, he joined the Everett, Mass., refinery of the company as a chemist in 1927 and subsequently held positions as general superintendent of that plant and of the Baltimore refinery. He was elected a member of the board in 1946.

William B. Maloney, assistant to the manager of employe relations, succeeds Mr. Naden as manager of employe relations of Esso Standard Oil Co. A graduate of Wesleyan University in 1933, he started with the company as a utility man in the Bayway refinery and became personnel manager of the Bayonne refinery in 1941. He was made coordinator of employe relations for the New Jersey refineries in 1946 and in 1947 became assistant to the manager of employe relations in New York.

* * *

Harold S. Jones is superintendent of Slaughter gasoline plant of Stanolind Oil & Gas Co., at Sundown, Texas. He was formerly superintendent of the company's cycling plant near Jennings, La.

Other personnel transfers in Stanolind's North Texas-New Mexico Division include the following: **Jack E.**

Personals

Fulgham, plant engineer at Slaughter, will advance to plant foreman there. **Kenneth L. Redman,** formerly a mechanical engineer at the South Jennings plant, is being transferred to Slaughter where he will be plant engineer.

Glenn A. Ayling, plant foreman at Slaughter, goes to Levelland, Tex., to become plant foreman at the gasoline plant, under construction there. **R. N. Hall,** who was process engineer in the Tulsa general office, will be plant engineer at Levelland. **Norris H. Trostel** also is being transferred to Levelland as operating engineer. He was formerly a mechanical engineer at the Luby gasoline plant near Bishop, Tex.

The South Fullerton gasoline plant near Andrews, Tex., also is receiving two new engineers: **Lloyd E. Childers,** formerly operating engineer at the Stano gasoline plant, Ulysses, Kans., and **Arthur H. Denny,** previously a member of the manufacturing department, Tulsa general office. Childers will become operating engineer at South Fullerton, and Denny will be plant engineer.

* * *

Mr. Beekhuis

William H. Beekhuis was elected a vice president of Standard Oil Co. of California. An economic counselor and formerly assistant comptroller he has acted as secretary of the executive committee for the past six months. He graduated from the University of California in 1930 and, in his career with California Standard, has been associated principally with its manufacturing activities.

* * *

J. P. Jurrius is chief engineer for CPIM, Royal Dutch Shell refinery subsidiary on Curacao Island, off the coast of Venezuela. He was formerly assistant chief engineer.

Mr. Jurrius

He entered the service of Bataafsche Petroleum Maatschappij at the Hague in 1921, was in engineering and pipeline work in Mexico until 1925, when he transferred to Maracaibo. In 1935 he was sent to Curacao where he served as chief maintenance engineer and assistant chief engineer. In 1946-47 he was in charge of building a refinery at Cardon, Venezuela.

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Personals

A. W. Ambrose, president of Cities Service Oil Co., was presented the President's certificate of award for employment of physically handicapped persons, at a Bartlesville Chamber of Commerce meeting.

* * *

Mr. Snyder

Lester M. Snyder is vice president of Arabian American Oil Co. He began his oil career with the Standard Oil Co. of California in 1931, and in 1939 went to Saudi Arabia as chief field engineer for Aramco. He returned to U.S. in 1947 to serve as assistant to the president. In his new assignment he will assist the president and executive vice president in the general administration of company activities.

* * *

Wiley G. Robinett was elected by directors assistant comptroller of Gulf Oil Corp. The contemplated retirement of John A. Ellen, assistant comptroller since 1933, was simultaneously announced. Mr. Robinett joined Gulf in 1915, after attending Texas A. and M. College. In 1926 he became assistant auditor of the manufacturing department, and has recently served as general auditor of refining and marketing operations.

* * *

Arvin S. Wellman is managing engineer of Asphalt Institute's Pacific Coast Division. Studying at Hendrix College and the University of Arkansas he was for several years with the Arkansas Highway Dept. A lieutenant commander in the Navy he supervised airfield construction in the South Pacific.

* * *

Dr. Curtis H. Baylor is assistant medical director of The Texas Co. A graduate of Johns Hopkins Medical School, he was professor of medicine at the American University of Beirut, Lebanon, returning to Johns Hopkins as professor and head of the university hospital medical service.

MEETINGS . . . for the Oil Man

NOVEMBER

7-10, American Petroleum Institute, Annual Meeting, Stevens Hotel, Chicago.
17, American Institute of Chemical Engineers, Third Annual Fall Symposium of New York Section, Hotel Statler, New York.
27-Dec. 2, American Society of Mechanical Engineers, Annual Meeting, Hotel Statler, New York.
28-Dec. 3, 22nd Exposition of Chemical Industries, Grand Central Palace, New York.

DECEMBER

4-7, American Institute of Chemical Engineers, Annual Meeting, William Penn Hotel, Pittsburgh.
9, Natural Gasoline Assn. of America, Panhandle - Plains Regional Meeting, Herring Hotel, Amarillo, Texas.
9, American Chemical Society, Southwest Regional Meeting, sponsored by Oklahoma Sections, Oklahoma City.
29-30, American Chemical Society, Division of Industrial and Engineering Chemistry, Columbus, Ohio.

JANUARY, 1950

9-13, Society of Automotive Engineers, Annual Meeting and Engineering Display, Book-Cadillac Hotel, Detroit.
16-19, First Plant Maintenance Show, Public Auditorium, Cleveland.

FEBRUARY

26-Mar. 1, American Institute of Chemical Engineers, Regional Meeting, Rice Hotel, Houston.
27-Mar. 3, American Society for Testing Materials, Committee Week and Spring Meeting, Hotel William Penn, Pittsburgh.

MARCH

26-30, American Chemical Society, 117th National Meeting (divided), Houston.
27-29, Western Petroleum Refiners Assn., 38th Annual Meeting, Plaza Hotel, San Antonio.

APRIL

3-6, National Assn. of Corrosion Engineers, Jefferson Hotel, St. Louis, Mo.
9-13, American Chemical Society, 117th National Meeting (divided), Philadelphia.
10-12, American Society of Lubrication Engineers, Hotel Statler, Detroit.
12-14, National Petroleum Assn., Semi-Annual Meeting, Hotel Cleveland, Cleveland.
16-20, American Chemical Society, 117th National Meeting (divided), Detroit.
24-26, Natural Gasoline Assn. of America, 29th Annual Convention, Texas Hotel, Fort Worth.

MAY

2-5, American Petroleum Institute, Refining Division, Annual Spring Meeting, Hotel Cleveland, Cleveland.
28-31, American Institute of Chemical Engineers, Regional Meeting, New Ocean House, Swampscott, Mass.

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EDITORIAL VIEWPOINTS...

Opinions and Comments on Current Topics

Refiners' Role in Preparedness Plan Should Be Self-Supporting

WHAT is the part refiners of the U. S. will be called on to undertake in any program to assure the nation the required supply of liquid fuels needed in another war?

Such a program, as related to supplying crude petroleum or other raw materials for liquid fuels, was presented to the industry by Walter G. Whitman at the recent American Petroleum Institute meeting in Chicago (see pg. 1222). While given as a meeting paper, the study is sufficiently comprehensive and concrete in its proposals to indicate that the subject has already been given considerable attention, likely in both industry and military quarters. The report therefore warrants the close consideration by the industry.

The Whitman report, "Liquid Fuel Supplies and National Security," is based on the premise that crude oil will be the mainstay, if not the total source of supply, of liquid fuels for another 30 years. Some of its proposals concern future developments in the refining industry as directly as they do the production and supply of crude.

One suggestion is that additional tankage be installed so that products could be stockpiled when an emergency developed and civilian rationing was put into effect, but before essential war consumption had developed on a large scale. The proposal is modest as compared with some plans for stockpiling crude and products that have been made. It would call for some 150,000,000 barrels of empty tankage, ready to receive "the first fruits of rationing" and it is estimated such a stockpile would receive 20% of our refinery production for 10 months.

This amount of tankage would cost around $200,000,000 and the report suggests that the government provide some of this additional tankage. The point is made that the industry is at present operating on too little product tankage for its present and coming peacetime needs and that the oil companies will themselves likely put in considerable new tankage. The building up of consumption of heating oils in the winter season, on top of the continuing motor fuel demand in those months since the war has had the effect of increasing the industry's product storage requirements. However, as in the past, plain economics will govern the amount of new tankage built to meet this condition. The concept of storage for security, ahead of an emergency, is a new principle for refiners to consider.

Again, the program presented at Chicago envisions prewar stockpiling of wartime specialty products in limited volumes—specifically, 1,000,000 barrels of toluene and 20,000,000 barrels of aviation alkylate. It is also assumed, and logically, that the technology of refining will further develop under peacetime conditions to provide higher yields of distillate products and lower yields of residual fuel oils. "Fundamentally," states the report, "that type of refinery development which increases the economic yield of products having unique values as liquid fuels contributes to security by conserving a quality resource for quality use."

Now that a tentative program for assuring adequate liquid fuel supplies in the event of another war has been made public, any further discussions arranged should plan to include the views and interests of the industry as widely as possible, small and large refiners as well as producers and others. The medium already exists for liaison between the industry and the military authorities through the Military Petroleum Advisory Board, set up two years ago to advise the armed services on petroleum matters affecting national security and defense.

Whatever the details of any program adopted, the Whitman report contains one general principle which will be endorsed by refiners as well as other branches of the industry. This is to the effect that the petroleum industry, of its own resources, can take all the necessary prewar measures required without government participation in its operations. This is particularly true since the bugaboo of our having to fall back on synthetic liquid fuels made in new costly plants to supplement petroleum has been laid at rest.

Petroleum is an active industry already flexible to a high degree in its ability to change its operations to meet large volume product requirements. Its peacetime volume products in the main parallel those needed in the conduct of a war. Prewar government participation in any security program adopted might prove a high price and a dragging influence, rather than adding to the effectiveness of the measures adopted.

Invasion of Inventors' Rights

THE lengths to which government agencies now go in prying into all activities of industrial concerns, including research, is well illustrated by a recent order of the Federal Communications Commission.

In conjunction with a television hearing FCC issued an order requiring all parties to the hearing to file abstracts of all their pending patent applications on inventions relating to transmitters or receivers for either monochrome or color transmitters. Also, each abstract was to be accompanied by a Power to Inspect Order, giving FCC's engineering staff the right to review the actual applications filed in the Patent Office.

The FCC unlawful order, made entirely on its own authority, would let even subordinate employes of this bureau pry at will into the results of millions of dollars worth of research carried on over many years by companies in the radio and television field. If carried out the FCC order sets a precedent for invasion by government agencies of research activities of industry generally.

Even more serious, meddlesome prying into industrial research on a wide scale would be possible under the National Science Foundation Bill pending in Congress as now drawn. Proponents of the bill as it stands have stubbornly fought against amending it to limit the powers of the Foundation to carry on just such invasions of the rights of inventors as are proposed in the order of the Federal Communications Commission.

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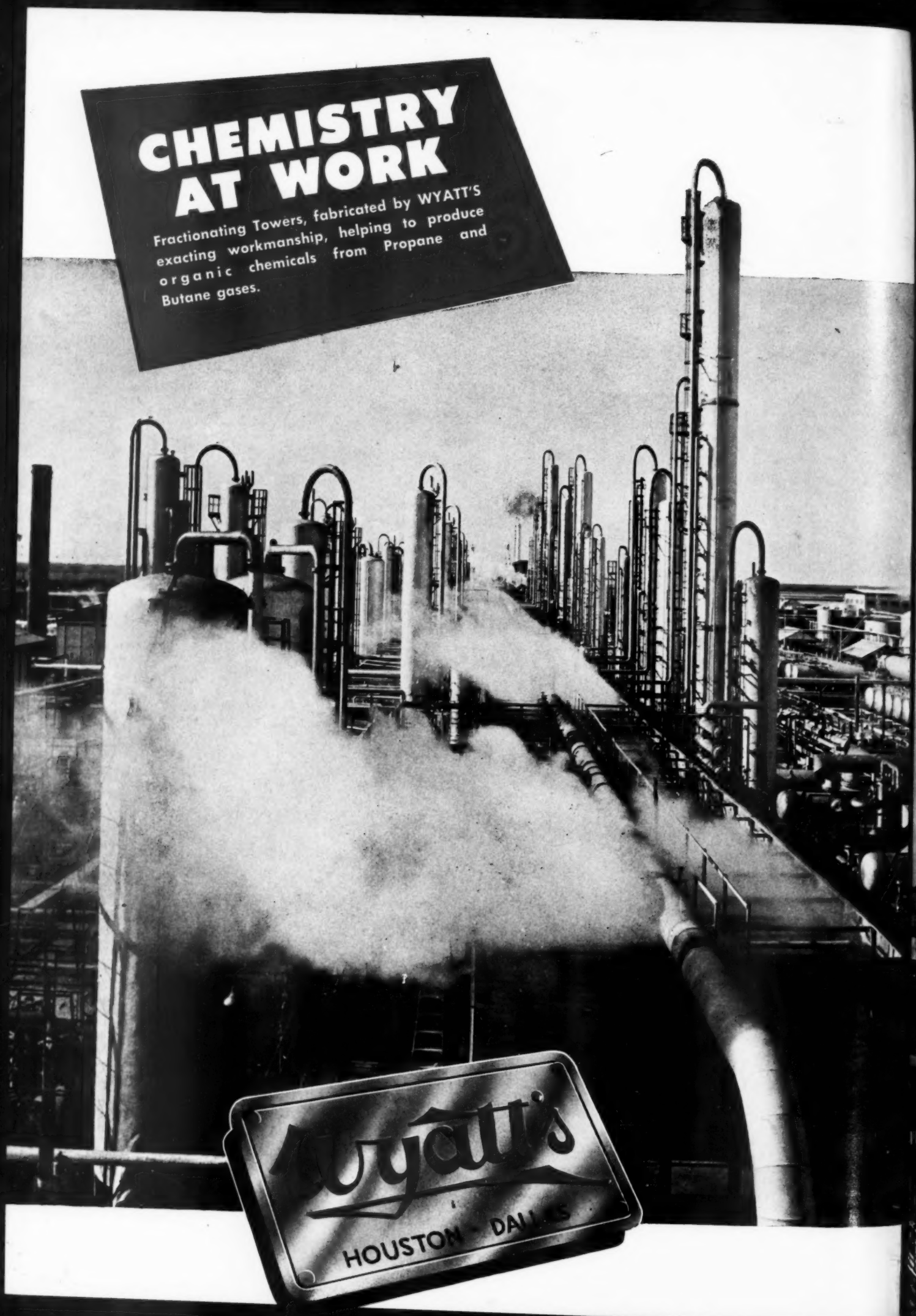
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